AUGUST • 1947

VOLUME XVIII NUMBER 12

the Petroleum Engineer

...ds for Operating Men

MEETINGS

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Sept. 10—Nomads, Jonathan Club, Los Angeles, Calif.

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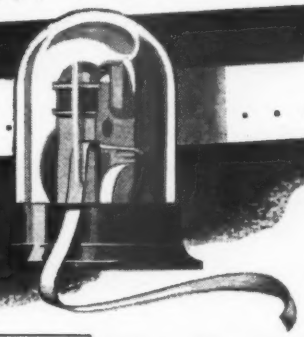

. FOR SALE OR LEASE .

1. As a whole, for operation at present site;

2. As a whole less two burner units and appropriate accessory buildings and equipment for operation at present site, or—

. . . FOR SALE . . . . .

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4. Two burner units only and their appropriate accessory buildings and equipment for dismantling and removal from site.

If the entire Plancor, except dwellings, not offered at this time, is sold for dismantling and removal from site, the dwellings will be offered at a later date.

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. . DELIVERY STATUS . .

Panhandle Carbon Company now operates this facility under an interim lease cancellable on 30 days' notice.

. . GAS SUPPLIES . . .

Gas is now being supplied by Phillips Petroleum Company under a contract with the present lessee, that runs through December 31, 1949.

Permits for use of natural gas in the manufacture of carbon black are issued by the Oil Conservation Commission of the State of New Mexico.

A prospective lessee or purchaser for operation of all or part of the Plancor at its present location should make his own arrangements to obtain necessary gas supplies.

. . SEALED BIDS . . . . .

Your sealed proposals on Standard Bid Forms will be received by War Assets Administration, Office of Real Property Disposal, 728 Fifteenth Street, Denver, Colorado, until 2:00 P.M., M.S.T., September 17, 1947, at which time all proposals will be publicly opened and read. Credit terms may be arranged. War Assets Administration reserves the right to reject any or all proposals. For a more detailed description of this property and for Standard Bid Forms write:

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The course of OIL

DOMESTIC OIL SUPPLY

Despite an unprecedented peacetime demand for for petroleum and petroleum products, the available supply of domestic crude is not critical. Any shortage that does exist is due to gathering, transporting, and distributing facilities being inadequate—particularly in certain parts of the country—to serve all refiners' needs and the present peak demand of the public. The shortage of facilities has developed because of the continued lack of steel following the end of the war.

In regard to the adequacy of domestic supply of petroleum, H. H. Hill, of the Standard Oil Company (N. J.), in an address before this year's annual meeting of the Chamber of Commerce of the United States, points out that: "Inasmuch as there has been a substantial increase in U. S. production since the first estimates of proved reserves were made, a more significant figure than the total reserves is the ratio of proved reserves to annual production which is sometimes referred to as year's supply at the current producing rate." This ratio, it should be noted, has ranged from a low of 5.8 in 1926 to a high of 14.6 in 1939. During the last few years "the ratio has remained fairly constant and at the end of 1946 the proved reserves were equivalent to 12.1 times the volume of production during that year."

In considering the long range domestic picture, Hill lists the sources of supply of hydrocarbon fluids as follows: "(a) Present proved reserves. (b) Additional oil from untested areas, including the continental shelf. (c) Substantial quantities from secondary recovery operations in partially depleted fields. (d) Substitute fuels from natural gas, oil shale, and coal.

"On the question of substitute sources of hydrocarbon liquids, the United States has large reserves of natural gas (approximately 160 trillion cu ft), a considerable percentage of which could be used for the manufacture of motor fuel and diesel oil at an estimated cost not much above that of obtaining the same products from petroleum. The reserves of oil shale and coal from which liquid fuels can be obtained are very large. It has been estimated that the oil shale reserves of the U. S. could yield approximately 98 billion barrels of oil while the 3 trillion tons of coal reserves could furnish about 6 trillion barrels of liquid fuel if it becomes necessary to rely on that source for hydrocarbon supplies."

THREE-WAY COOPERATION

Speaking at the annual meeting of the Oil Compact Commission at Great Falls, Montana, this week, Mr. Hallanan, chairman of the National Petroleum Council, asserted that three-way cooperation between the industry, the States, and the Federal government is necessary to safeguard the national defense. "We had that three-way cooperation during the war," he said, "and through that cooperative effort we met the greatest challenge of all history. Very simply, what we are doing now is carrying forward into peacetime the same sincere cooperative enterprise which was so fruitful in time of war — and without the controls which were imposed in the national emergency.

"More than ever before," the Council chairman continued, "We must be aware that our national security—as well as the destiny of civilization—is inseparably linked with the petroleum industry of America. Modern warfare has made us conscious that our first obligation is to maintain a strong and free industry—but an industry which recognizes that its first duty is to be prepared to answer any call that our government may find necessary to make upon it.

"To be prepared for any eventuality, there must necessarily be a close bond of cooperation and understanding between the industry and the State and Federal governments. I mean that kind of cooperation that brings forth the maximum of performance without the surrender of any vestige of a self-dependent industry. *That* we propose to continue because we know it is the only road the industry can travel and fulfill its responsibility."

Mr. Hallanan declared that work of the Oil Compact Commission had prevented America from becoming a "have-not" nation in oil. He said the Commission had charted a course of action that had brought about a complete evolution in the development of the nation's oil and gas reserves. "Your efforts not only have been worthy from the standpoint of serving the public interest," he said, "But they have also represented a constructive and worthwhile purpose in saving the oil industry from its own self-exploitation." He declared that the work of the Commission was "responsible for the fact that in spite of the tremendous increase in consumptive demand that was laid upon the industry during the war, and as further increased since the war, we are still a self-sustaining nation in oil, and our gas reserves are almost untouched."

K. C. S.

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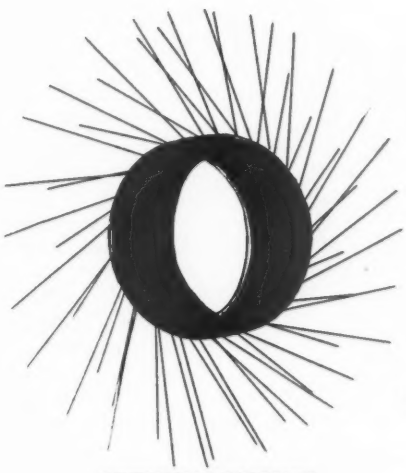
6. *Blowing out* and *cratering* of wells on the outside of the surface casing.
7. Production of "foreign" oils, gases and waters from perforations they are not supposed to come through.
8. The *tightening up* or complete *shutting off* of production zones by squeezing.



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SCANNING WASHINGTON'S OIL HORIZON

By MILBURN PETTY

WASHINGTON—Military leaders apparently have become convinced that development of a synthetic fuel industry in the United States, capable of producing a million barrels daily of synthetic oil, is the only sure way of attaining the self-sufficiency required by national defense.

Military thinking keeps coming back to the basic fact that we entered the last war with crude oil productive capacity of a million barrels daily in excess of demand whereas this reserve capacity has just about disappeared now.

The Middle East and Latin America may be the short term solution to the tight supply outlook but, long range, the military is turning to synthetics as the ultimate answer to the need for adequate domestic fuel resources in case of another war. And the international situation being what it is, the military can be expected to lose no time in pushing synthetics. Indeed, there have been conferences recently between Interior Department and the Army and Navy at Cabinet level on ways and means of speeding up the synthetic fuel program, converting it from research to large scale production as soon as possible.

Outcome may be that a plant construction program, costing several hundred million dollars, will be submitted at the next session of Congress either by the Secretary of Defense or by Interior, strongly backed by the military. This program probably will call for building four synthetic plants each with a capacity of 25,000 to 30,000 bbl daily—to make liquid fuels by retorting oil shale, by hydrogenation of coal, and by the Fischer-Tropsch process using natural gas and coal.

Preliminary to this, the Bureau of Mines—at the request of the military—has launched an immediate survey for suitable locations for synthetic plants with a capacity of a million barrels daily.

Present plans contemplate utilizing of oil shale, coal, and natural gas in the first plants to be built but, in the long run, shale is expected to get the big play. First, the raw material has no other use; second, the Navy has control of more than 158,000 acres of rich oil shale lands in Colorado and Utah containing many billions of barrels of oil; and third, the Navy estimates that plant costs and manpower requirements of oil shale plants would be much less than plants using coal or gas.

●

Speaking at the dedication of Interior's oil shale demonstration plant at Rifle, Colorado, last spring, Commodore W. G. Greenman, USN, director of Naval Petroleum Reserves, said that while studies of mining and treating costs are not conclusive, "they indicate that to establish a commercial production of 500,000 bbl of shale oil a day, 15 plants will be required.

"It is estimated," Greenman continued, "that these plants would require a million tons of steel, cost $800,000,000 to construct, and employ an operating staff of 9000 men. The cost of the mines from which the shale must be produced is estimated at $100,000,000 and 18,000 men would be required to mine and handle the shale to the retorts.

"To provide the same amount of oil each from coal and natural gas using the Fischer-Tropsch process in both cases, it is estimated that 25 plants would be required to handle each of the raw materials with a total steel requirement of 8,500,000 tons, construction costs of $3,500,000,000, mine costs of $550,000,000, plant staff of 75,000 men, and mining and maintenance crew of 46,000 men.

"Thus," Greenman pointed out, "to provide 1,500,000 bbl of synthetic fuel per day using shale, coal, and gas, the following estimated requirements are indicated: Total plants, 65; steel, 9,500,000 tons; construction costs, $4,300,000,000; mine costs, $650,000,000; and staff for plant operations and mining, 148,000 men."

Greenman went on to say that these figures "indicate the task ahead if the nation is to remain self-sustaining in the face of a natural petroleum shortage in the not distant future." But planning and construction of commercial synthetic plants cannot be accomplished overnight, so Interior's program must be vigorously prosecuted, he added.

Studies by the Bureau of Mines indicate that synthetic plants smaller than those contemplated by the military would be nearly competitive with petroleum refineries. It is estimated by the Bureau that for a plant producing 10,000 bbl daily of motor fuel from sub-bituminous coal at $1.50 per ton the net cost would be 8.7c per gallon while a 20,000-bbl shale oil plant could make synthetic crude oil for $1.92 per barrel exclusive of profit and interest on investment.

The military's initiation of plans to speed up the building of large-scale synthetic fuel plants is but another indication of their growing interest in the overall petroleum picture, both short and long range.

●

Short range, the military has been considering the importation of crude oil from Mexico, Venezuela, or the Middle East in Navy tankers and exchanging it with United States refineries for products needed by the military. Already, Navy tankers are importing fuel oil from Persian Gulf refineries to the East Coast at the rate of 500,000 bbl per month.

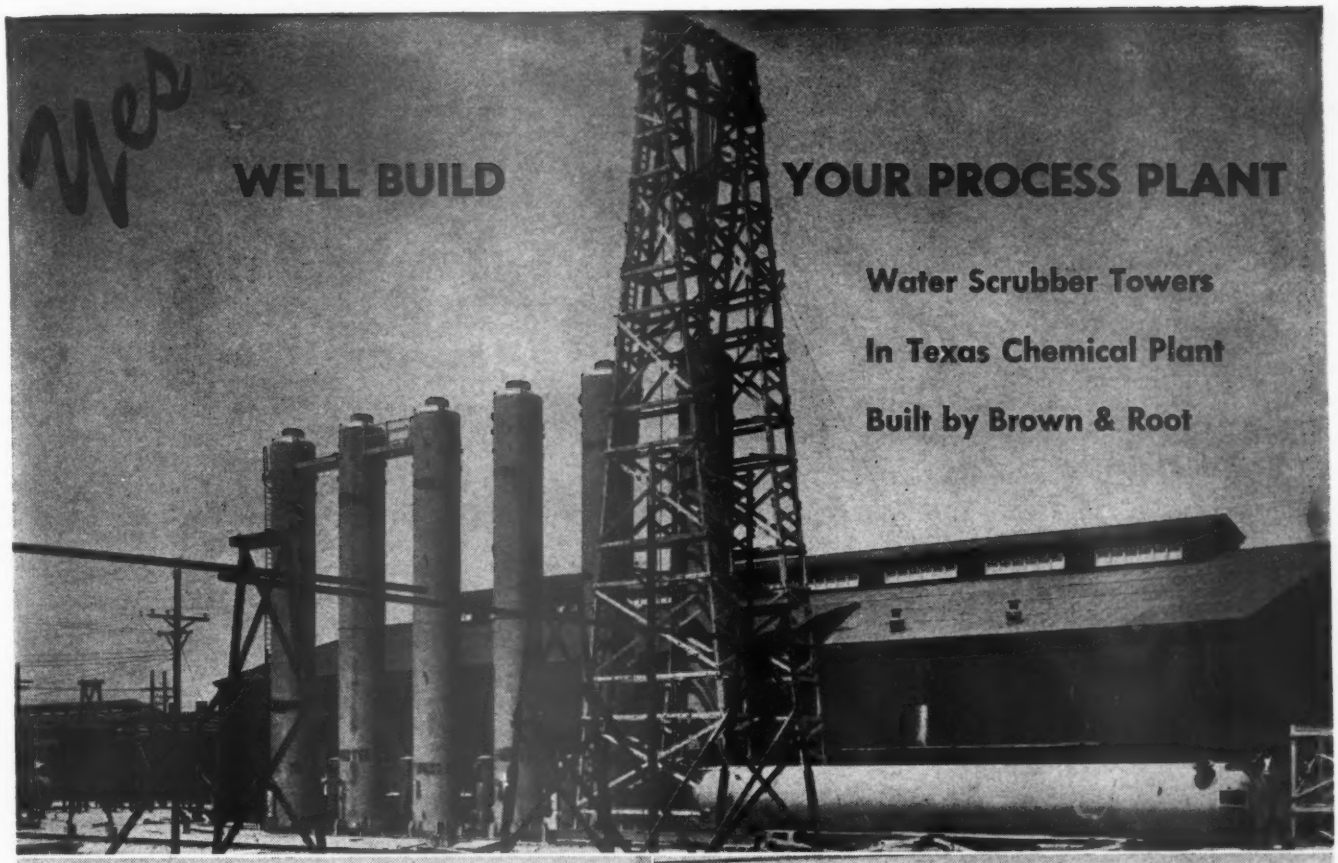
Long range, the question of an assured oil supply undoubtedly will be one of the most important to come before the National Security Resources Board, set up under the new Army-Navy merger law to program for effective use of natural and industrial resources in case of war. This board will be made up of executives from various government agencies, including Interior. It will have as chairman a civilian who will report directly to the President.

It can be expected that NSRB and the military will have something to say in developing overall policies regarding federal leasing of submerged lands as a result of the Supreme Court's decision in the California tidelands case. One idea being tossed around is that some of these offshore submerged lands should be earmarked as government oil reserves. Another is that in leasing these lands for oil and gas development the government should have first call on any oil or gas produced. With an assured raw material supply, products could be easily obtained by exchanges, it is argued.

Meanwhile, the growing interest of independent producers and refineries in Middle Eastern oil is cited by some government officials as "the handwriting on the wall" as to a continuing tight crude situation in the United States.

Foremost among these is the group of a dozen large independents, with Phillips Petroleum Company taking the lead, organizing the American Independent Oil Company which, among other activities, plans to seek a foothold in the Middle East. Presidency of this group has been offered to Ralph K. Davies, deputy petroleum administrator during the war and formerly vice president of the California Standard.

The corporate powers of the AIOC are so broad, however, that they might even include large scale oil operations on the Continental Shelf when confusion over the submerged lands situation is cleared up.



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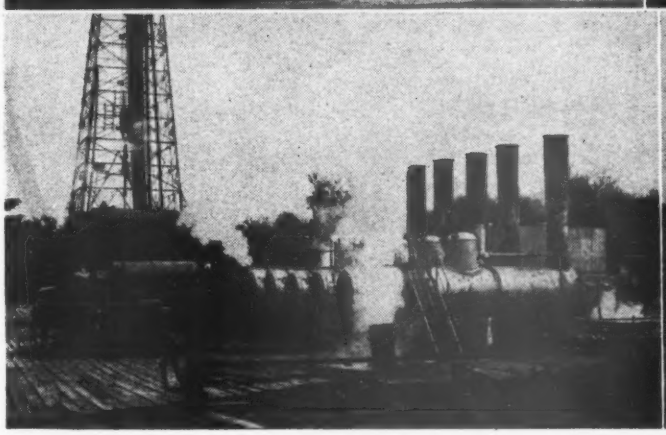

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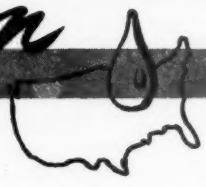


By H. J. STRUTH,*
Petroleum Economist

DEMAND OUTLOOK. Studies of demand trends through the first quarter of 1948 point to a total increase this year over 1946 of about 8.7 per cent. Increases expected by products are motor fuel 6.3 per cent; kerosene 19.4 per cent; distillate fuel oil 17.7 per cent; residual fuel oil 6.1 per cent; other products 7.7 per cent. Demand for all oils this year will probably average 5,786,000 bbl daily, against 5,321,000 bbl in 1946. Demand in the first quarter of 1948 may average 6,135,000 bbl daily, compared with a projected demand in the fourth quarter of this year of 5,970,000 bbl daily.

*Editor, *THE PETROLEUM DATA BOOK*

SUPPLY ADEQUATE. Increased crude production and greater output of natural gasolines and condensates, supplemented by greater imports, indicate a petroleum supply more than adequate to meet the unprecedented demand being experienced this year. Supply of all oils, including imports, will probably average 5,825,000 bbl daily, against the demand of 5,786,000 bbl. This means the industry will be able to increase stocks of crude and products by about 39,000 bbl daily, totaling 14,200,000 bbl for the year.

CRUDE PRODUCTION. Production of crude oil will probably show an increase this year over last year of about 5.3 per cent. Daily average production this year will be about 5,000,000 bbl daily, against 4,749,000 bbl in 1946. Production in the last quarter of the year will average 5,100,000 bbl daily and that rate is expected to be maintained into the first quarter of 1948. This contemplates attaining maximum efficient rates in most fields, but the bulk of the increased domestic supply will come from fields in Texas and Louisiana.

FOREIGN TRADE. Imports of crude and products are definitely greater this year and are likely to grow larger next year. Imports of all oils will probably average about 465,000 bbl daily, against 370,000 bbl in 1946. The outlook is for an import volume in the first quarter of 1948 of at least 490,000 bbl daily, with the prospect of well over 500,000 bbl daily by mid-year. Export volume has been greater this year in response to heavier foreign requirements. Net results, however, will probably reverse the trade balance, with imports exceeding exports by about 12,000 bbl daily.

Comparative Statistics, July, 1947

*All figures are computed on a Bureau of Mines' Basis**

	July 1947(p)	June 1947(p)	July 1946	This year to date	Last year to date	Per cent change
Wells drilling	4,250	4,500	3,650	4,250	3,650	+16
Total wells drilled§	3,077	2,744	2,578	18,123	16,510	+10
Development wells	2,616	2,277	2,172	15,381	14,087	+ 9
Oil	1,597	1,413	1,251	9,564	8,406	+14
Gas	293	265	302	1,789	1,638	+ 9
Dry§	726	599	619	4,028	4,043	0
Per cent dry	27.8	26.3	28.5	26.2	28.7	— 2.5
Wildcat wells	461	467	406	2,742	2,423	+13
Oil	63	66	43	400	333	+20
Gas	27	21	12	115	70	+64
Dry	371	380	351	2,227	2,020	+10
Per cent dry	80.5	81.4	86.5	81.2	83.4	— 2.2
Crude supply*	165,500	¶161,350	159,564	1,105,204	1,049,686	+ 5
Daily average	5,339	5,378	5,147	5,213	4,951	
Crude demand‡	170,200	¶163,940	158,306	1,099,077	1,043,626	+ 5
Daily average	5,490	5,465	5,107	5,184	4,923	
Crude stocks	236,300	¶241,000	229,319	236,300	229,319	+ 3
Day ssupply	43	44	45	43	45	
Natural gasoline production	11,100	¶10,660	9,408	74,243	65,427	+13
Daily average	358	355	303	350	309	
Motor fuel production	74,000	69,670	67,445	468,669	437,658	+ 7
Daily average	2,387	2,322	2,176	2,211	2,064	
Gasoline yield, per cent	40.4	39.8	39.8	39.7	38.5	+ 1.2
Motor fuel demand‡	78,400	74,140	71,796	474,761	444,622	+ 7
Daily average	2,529	2,471	2,316	2,239	2,097	
Motor fuel stocks^	82,500	86,900	86,718	82,500	86,718	— 5
Days supply	33	35	37	33	37	
Fuel oil production	64,500	61,130	60,649	425,385	425,354	0
Daily average	2,080	2,038	1,956	2,007	2,006	
Fuel oil demand‡	59,080	59,480	55,501	490,772	447,017	+10
Daily average	1,906	1,983	1,790	2,315	2,109	
Fuel oil stocks	93,800	85,000	91,885	93,800	91,885	+ 2
Days supply	49	43	51	49	51	
Refinery still runs	161,200	153,750	150,541	1,041,478	998,965	+ 4
Daily average	5,200	5,125	4,856	4,913	4,712	
All refined stocks	259,500	253,730	261,452	259,500	261,452	— 1
Days supply	47	45	51	47	51	

Economic Position of U. S. Petroleum Industry

Seven Months Ending July 31, 1947

	Normal	Actual	Per cent of normal
Drilling*** (wells completed)	18,020	17,025	94
Production (daily crude output)	4,865	4,943	102
Refining (daily still runs)	4,900	4,913	100
Stocks (crude and refined)	500,000	495,800	99
Price of crude (per bbl)	$1.88**	$1.94	103

Current Crude Oil Prices

U. S. average	$1.94	Louisiana	$1.92
Texas	1.91	Arkansas	1.73
California	1.86	New Mexico	1.70
Oklahoma	1.93	Mississippi	1.72
Kansas	1.92	Illinois	2.06
		Other states	2.55

Basic crude prices

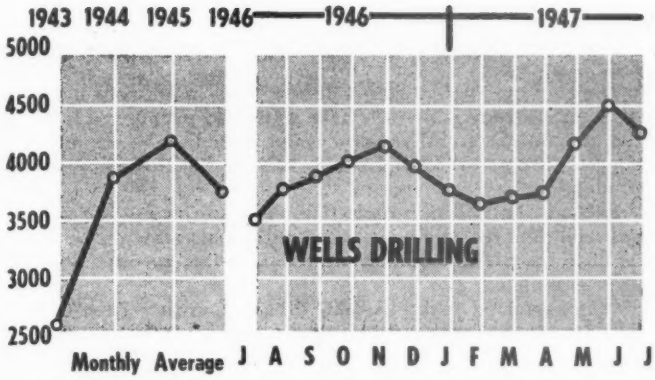
Oklahoma-Kansas (36 gr.)	$1.87
Texas Gulf Coast (36 gr.)	2.07
East Texas	1.95
West Texas (36 gr.)	1.74
California Signal Hill (26 gr.)	1.91
Pennsylvania, Bradford	4.30

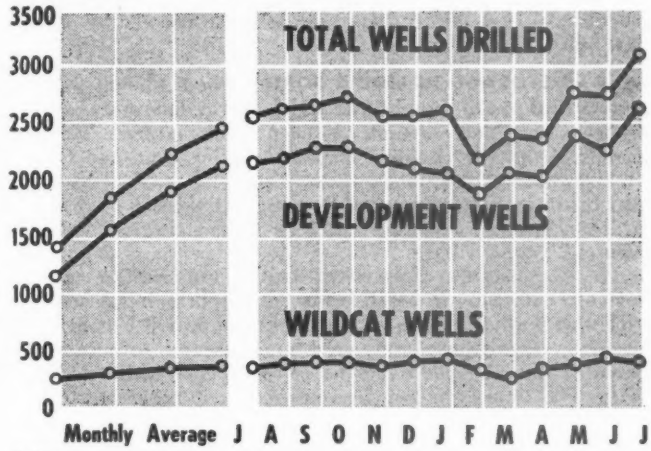
Drilling and Production Statistics by States

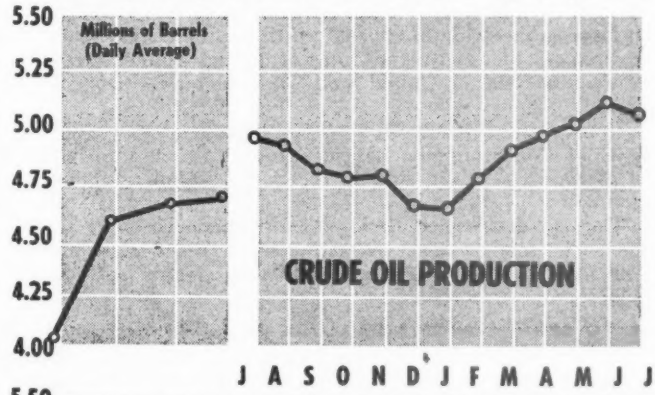
	July 1947(p)	June 1947(p)	July 1946	This year to date	Last year to date	Per cent change
Total wells drilled§	3,077	2,744	2,578	18,123	16,510	+ 10
Texas	930	745	670	5,178	4,633	+ 12
California	162	175	157	1,160	1,068	+ 9
Oklahoma	311	382	289	2,324	1,471	+ 58
Kansas	236	197	175	1,432	1,137	+ 26
Louisiana	167	111	111	798	749	+ 7
Arkansas	21	26	13	163	103	+ 58
New Mexico	42	49	23	310	211	+ 47
Mississippi	52	59	13	282	139	+103
Illinois	205	181	231	1,132	1,285	— 12
Other states	951	819	896	5,344	5,714	— 6
Wildcats drilled	461	467	406	2,742	2,423	+ 13
Texas	159	168	143	994	927	+ 7
California	34	28	16	204	126	+ 62
Oklahoma	65	70	50	465	260	+ 79
Kansas	45	41	25	219	163	+ 34
Louisiana	31	23	22	154	135	+ 14
Arkansas	6	6	2	35	20	+ 75
New Mexico	2	7	0	26	28	— 7
Mississippi	8	13	4	53	45	+ 18
Illinois	47	61	69	236	297	— 21
Other states	64	50	75	356	422	— 16
Daily crude production	5,081	5,117	4,922	4,943	4,719	+ 5
Texas	2,247	2,293	2,217	2,160	2,079	+ 4
California	918	918	874	906	859	+ 5
Oklahoma	383	388	375	378	374	+ 1
Kansas	298	292	274	284	260	+ 9
Louisiana	439	434	399	427	381	+ 12
Arkansas	82	82	78	81	77	+ 5
New Mexico	110	108	101	107	100	+ 7
Mississippi	97	95	64	90	59	+ 53
Illinois	179	186	208	186	208	— 11
Other states	328	321	332	324	322	+ 1

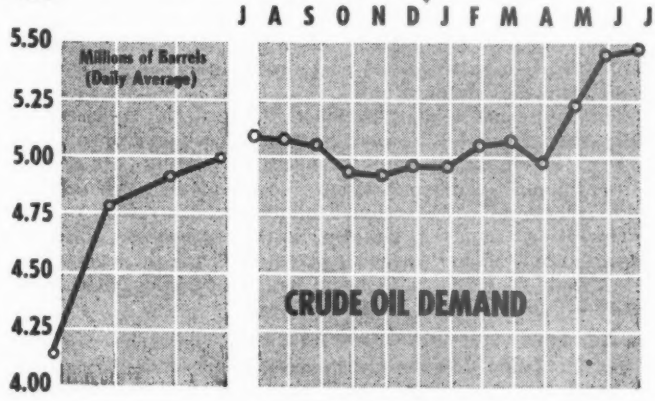
*Unless otherwise stated all figures represent thousands of barrels. ***Does not include input wells. (p) Preliminary. *Includes domestic production and imports.
‡Total demand, including exports. **Price 1926 (Index 100). ^Includes finished and natural gasoline. §Includes service wells. ¶Revised.

Preliminary estimates based upon data furnished by American Petroleum Institute, U. S. Bureau of Mines, State Agencies, and other official sources









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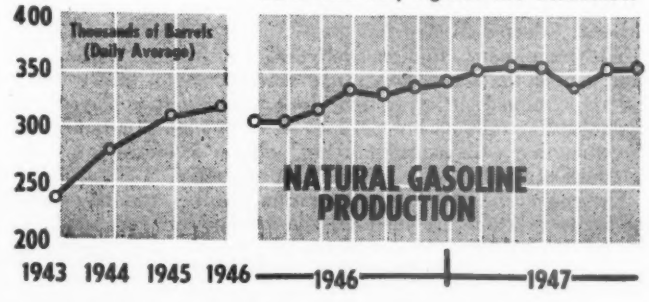

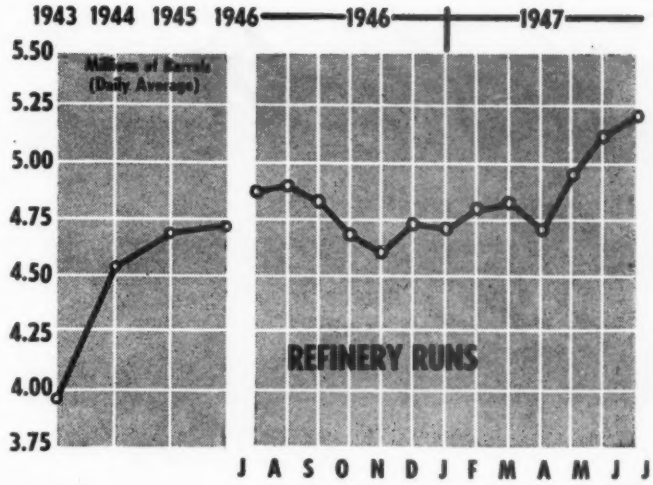

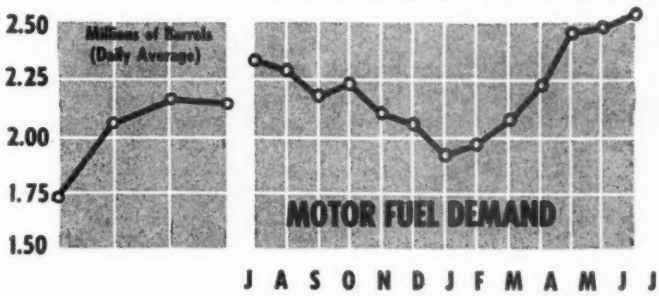

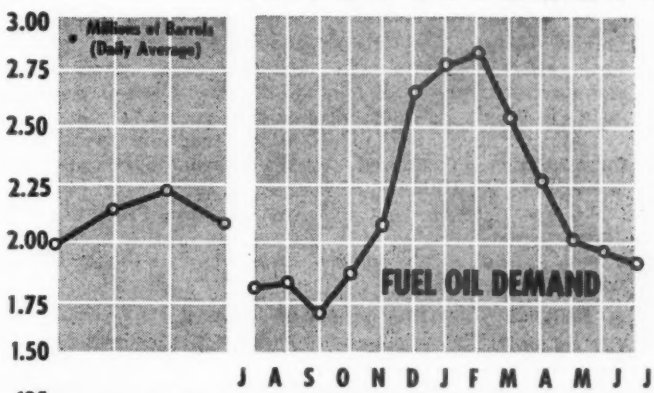

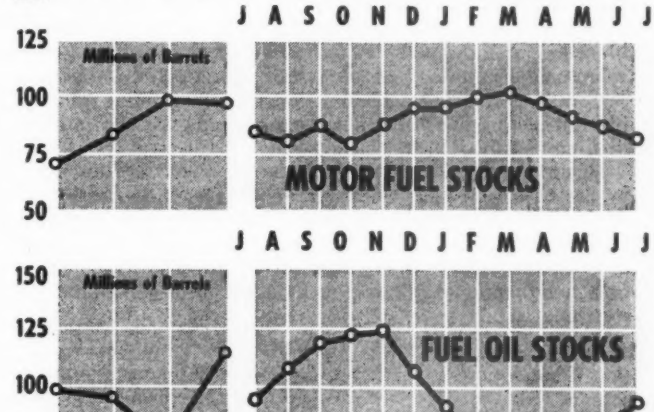

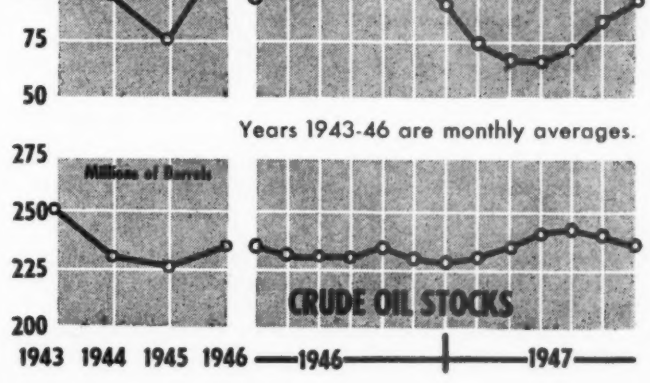

Years 1943-46 are monthly averages.

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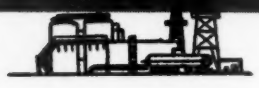

● **ASKS TIDELANDS RULING BE RECONSIDERED.** The state of California has asked the Supreme Court to reconsider its decision that so-called tidelands off the California coast belong to the federal government.

Fred N. Howser, California attorney general, submitted a petition for rehearing. He asked "that the majority opinion should be reversed, or that the petition should be granted and the case set for further argument."

Howser challenged the court's reasoning in citing the action of federal departments to support federal title to offshore lands.

"If the court is to consider itself bound by the assertions of federal officials," the California petition said, "then the court has, in effect, abdicated its function as impartial arbiter between states and federal government and the executive department becomes the final arbiter in a dispute such as this."

The petition referred to an 1890 Supreme Court decision that there was no land area under the sea adjacent to the coast which belonged to the United States.

"It is at once apparent," the petition said, "that when this deeply-imbedded rule of law is given application to the issues herein, the majority opinion is erroneous and should for that reason be reversed."

● **HUMBLE SUSPENDS TIDELANDS WORK.** The Humble Oil and Refining Company has suspended activities in the Gulf of Mexico offshore from Louisiana.

In a prepared statement the company said it had leased 10 blocks of land from the state of Louisiana for oil and gas development in the Gulf of Mexico off the coast of Louisiana.

Contracts had been entered into for the building of drilling platforms and the company was preparing for the immediate drilling of two wells on this acreage.

Due to the decision of the Supreme Court of the United States in the case involving tidelands off the coast of California in which it was held that the United States and not the state of California is the owner of these tidelands, Humble has decided to postpone drilling operations on its Louisiana tideland holdings pending favorable action by the courts or Congress, the statement said.

● **UNIT PLAN FOR WEST EDMOND.** The Oklahoma Corporation Commission has ordered that the 30,000-acre Hunton lime zone of the West Edmond oil field be unitized for complete operation as a single lease.

This is the first order issued under the 1945 state law providing for unit operation of oil and gas fields. The statute is the first ever passed by an oil-producing state.

The unitized operation of the field is expected to begin about September 1, at which time approximately one-half of the wells in the field will be closed down and oil production taken from the remainder. The present production is averaging 40,000 bbl a day and under the new program it is expected to be increased to approximately 55,000 bbl a day.

The plan covers some 30,000 acres of leases in Oklahoma, in Canadian, Logan, and Kingfisher counties. There are 740 wells producing on more than 300 leases.

To date the Hunton lime zone has produced an estimated 60,000,000 bbl of oil from the reservoir, which is estimated to have contained 600,000,000 bbl when the field was discovered just four years ago.

Under the plan, first step will be to shut in all wells having a high gas-oil ratio. This will have a twofold purpose: (1) Curb the amount of natural gas now being vented to the air, and (2) equalize the pressure in the reservoir so that the allowable oil production may be increased.

Second phase of unit operation will be injecting the natural gas back into the producing zone. A third possible phase would be flooding the oil reservoir with water after gas-injection had been completed.

It is estimated that 140,000,000 bbl of oil may be produced by present methods—flowing and pumping. Selective production is expected to increase this amount by 10,000,000 bbl, and gas injection would add an additional 40,000,000 bbl. If waterflooding is used, the recovery may be again boosted by 30,000,000 bbl.

● **GAS STORAGE IN LIQUID FORM.** A new method for storing natural gas in liquid form, which will reduce storage space by more than 99.8 per cent, has been developed by L. F. Stutzman, assistant professor of chemical engineering, and George H. Brown, instructor, at Northwestern University's Technological Institute, it is announced. By their method, 800 cu ft of natural gas may be contained in 1 cu ft of storage space, it is asserted.

The Northwestern University scientists reduced the temperature of natural gas to 260 F below zero by bringing it into contact with liquid nitrogen at a temperature of 320 F below zero during a seven-month study on a huge research project, which revealed that the gas could be stored economically in liquid form. The liquid gas can be returned to its gaseous state by reducing refrigeration.

● **PROTEST INVOLVES OIL EQUIPMENT.** An American protest to Moscow involving $1,000,000 worth of oil machinery missing in Romania clouds Russia's hope of getting lend-lease refinery equipment from the United States, it is announced from Washington.

Delivery of $18,000,000 worth of post lend-lease supplies, much of it oil equipment, has been stopped by congress because of Moscow's delay in settling the Soviet Union's wartime account.

The state department disclosed a formal note had been handed the Soviet foreign office, protesting Russia's failure to pay for 7000 tons of oil equipment removed from Romania by Red army troops.

● **TO BEGIN ETHIOPIA DRILLING.** Actual oil drilling operations by the Sinclair Oil Corporation, which has a 50-year monopoly concession for oil exploration throughout Ethiopia, are expected to begin soon following the recent arrival at Djibouti of three shiploads of oil-field and geological equipment from the United States.

The equipment is being transported by rail to Diredawa. Additional equipment is en route from New York on a fourth ship.

From Diredawa the equipment will be transported overland into Ethiopia's Ogaden Province, now under British military administration, but sovereign Ethiopian territory.

Operation camps will be set up in three prospective oil-bearing areas of Ogaden Province. A party of 12 American geologists is en route to Ethiopia to begin actual operations. Unskilled labor will be employed locally.

● **CO-OPERATIVE WINS KANSAS CASE.** The Kansas Supreme Court has ruled that the Consumers Co-Operative Association of North Kansas City, Missouri, was authorized under Kansas statutes to carry out its extensive industrial activities and should not be dissolved as was requested in a suit brought by Attorney General Edward F. Arn.

The unanimous opinion, delivered by Justice William A. Smith, held that the co-operative marketing act, under which the association is incorporated, does not limit it to the sale of agricultural products but permits it "to engage in any activity in connection with manufacturing, selling, or supplying to its members of machinery, equipment, or supplies."

The court ruled that the association has the authority under the act to manufacture such supplies and equipment, including the refined products of crude oil, and to own and operate oil wells and pipe lines with which to carry out these activities.

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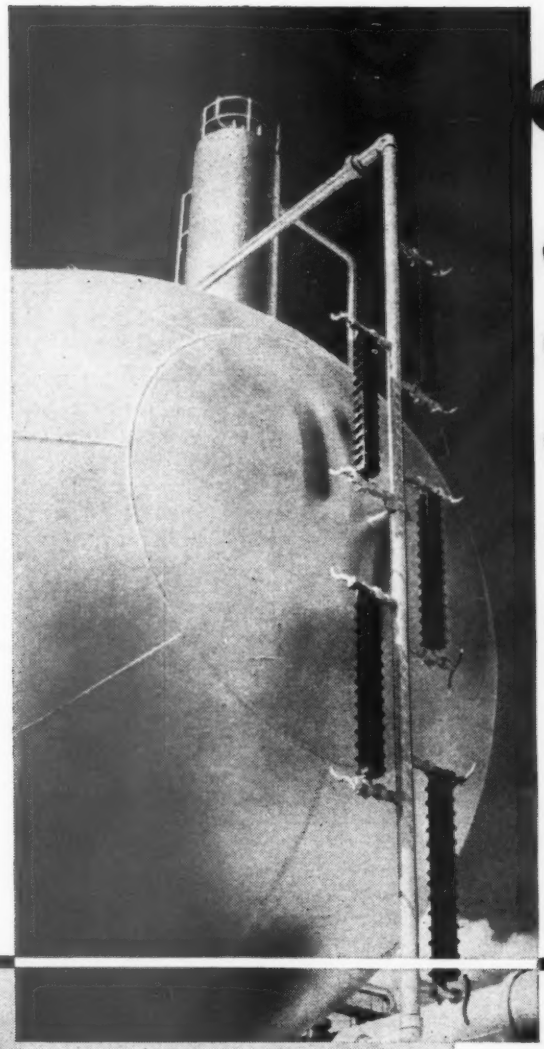

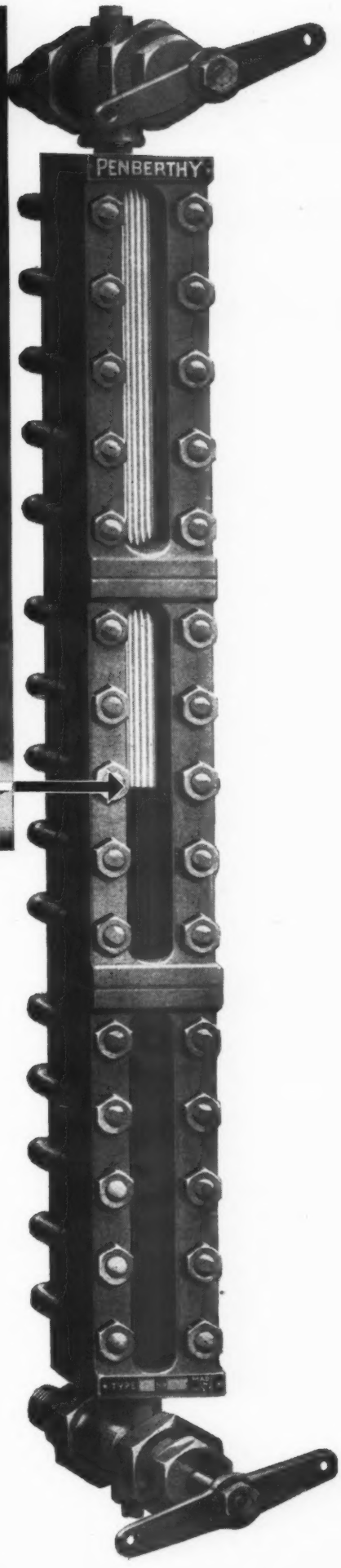

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current oil field operations

Exploration wells that have found production.

● **LOUISIANA.** Atlantic 1 Haas Investment, 10-2s-2e, Avoyelles. IP 160 B 8562-72 ft.

Texas 1 Lafourche Basin Levee Dist., 30-20s-25e, Jefferson. 43 B cond & 6 MMCF gas PD. 13879-904 ft. Deepest production.

Texas 10 State-Rabbit Island Bayou Sale pool, Iberia. 5535 M ft gas, 10545-68 ft. New pay.

Charles C. Lowery's 1 Stiles, 18-21n-16w, Caddo. 40 BOPD 2290-442 ft.

Union Sulphur 1 W. E. McFatter, 34-7s-10w. Gas & cond from above 6400 ft.

Magnolia 46 Cameron Meadow Ld., Cameron Meadow pool, Cameron, 118.68 BOPD 41.8°, 8834-36 ft. New pay.

● **TEXAS.** Humble 1 McKnight James Sur., Wood. 79.35 B 52° cond and 1472 M ft gas. Rodessa, 8935-65 ft. First gas-distillate and deepest pay in county.

Tidewater - Hudgins GH&H Sur., Wharton. Wet gas from 6720-22 & 6708-12 ft.

W. W. Harvey et al 1 H. S. Livingston, 26-146-Grimes CSL, Taylor. 20 min DST 120 ft oil. Hope, 2807 ft.

Barnsdall 1 Camp Sec 13, D-8, EL&R Sur., Hale. Oil show in Permian, 6164-67 ft.

Hiawatha 1 Johnson, Quirk Sur., San Augustine. 115 BOPD 42.3°. Pettit, 8130-60 ft.

Pure & Humble 1 Cowden, 24-A52-PSL, Andrews. DST 1200 ft oil, 8555-605 ft. Third pay.

Panhandle Ref. 1 Zotz Clark & Plumb Sur., Archer. Est. 25-50 BOPD. Strawn, 4050-84 ft.

Warren 1 M. J. Henderson Young. DST 5 BOPH. Strawn, 2650 ft.

Texas 5 Handy S. Stewart Sur., Grayson. 307 B 39.8° oil, new Strawn pay, 2102-62 ft.

Wm. H. Hunt Trust Estate 1 Spencer-Crane, Live Oak Peninsula, Aransas. 185 BOPD. 7126-36 ft, gas and cond 7058-65 ft.

Magnolia in "76" field area, Duval. DST 320 ft gas Cole sand, 1297-1308 ft. DST 780 ft oil 1322-29 ft.

Forrest 1 H. C. Obelgoner, Lavaca. Gas & cond 7511-16 ft.

Rowan & Hope 1 Rio Oil Corp, Bee. Gas & cond Slick sand, 7525-65 ft, and Wilcox 7841-68 ft.

Continental 1 Kitty West Burns, Live Oak. 1970 MCF gas PD & 2 B cond, 10,170-90 and 10,236-48 ft.

Crescent 1 Nellie K. Gramm, Eliza Sante Sur., Burleson. 18¾ B 38.3° oil, 3440-50 ft.

Sunray 1 Brandt, Hancock Sur., Goliad. 15-min DST 30 B 31.4° oil Luling sand.

Humble 1 Mitcham, 12-AB-DS&E, Crockett. DST 40 BOPH & 500 MCF gas PD Ellenburger, 8097-120 ft.

First Nat'l Bank of Mission 1 Jay Simmons, San Jose grant Starr. 425 B oil Frio 6100 ft.

Warren 1-A Deats, 3-BS&F Sur, Kendall pool, Young. 109.7 BOPD 43°. Mississippian, 4549-61 ft. New pay.

Jack W. Frazier 1 Fred Swenson J. Dever Sur., Wharton. Gas 4703-11 ft.

Sinclair Prairie & Atlantic 1-66 University, Crockett. 10-min. DST 10 MMCF gas & 60 ft cond Ellenburger 7390-438 ft.

● **OKLAHOMA.** George Pace 19 Watkins, NW NE SE, 21-2s-7w, Empire-Comanche pool, Stephens. 5 min DST 40-50 MMF gas. Arbuckle, 3184-202 ft. New pay.

L. G. Wheeler et al 1 Sorie, NW NW NW, 19-19n-4e, Payne. 10 BOPH and 1 MMCF gas daily. Wilcox, 3800-20 ft.

Skelly 1 Chapman, NE NE SE, 25-4-3w, Garvin. 329 B oil in 9 hr, 7486 ft.

Ohio 1 Tims SE SE NW 6-3-5 Grady. 15-20 B DST 4334 ft.

Davon 1 Brunken, NE NW NE, 32-23-4w, Garfield. 50-75 BOPD 2nd Wilcox, 6038 ft.

Stanolind 1 Sims, NE NE SE 2-1s-4w, Stephens. Show Springer, 4030 ft & 10 stained zones to 5145 ft.

Faultline 1 School Land, CNE NW, 36-10n-2w, Cleveland. DST 2MMCF gas, Bartlesville, 6443 ft.

Cities Service & Mid-Continent 1 Rogers-B, SW NE SE, 25-4n-4w, Garvin. 30 BOPH and 250 MCF gas PD.

Phillips 1 Chapman, NW SW NW 1-10-4e, Pottawatomie. Swb 2½ BOPH, 4147 ft.

Davon 1 Dye, SE SW NW, 15-14n-5e, Lincoln. 18 BOPH & 4 MMCF gas daily. Prue sand, 3370 ft.

Carter 1 Reviere, NE SW SE, 10-1s-5w, Stephens. DST gas & 2350 ft oil, 4663 ft.

Gulf 1 Frazier, C NE NW 11-12n-2w, Munger pool Oklahoma. DST 54-84 MCF gas PD & 30 ft oil. Bartlesville, 6081-94 ft. New pay.

Mid-Continent 1 T. Meadors. NW NW NW, 36-9n-10e, Hughes. 3 MMCF gas PD. Booch, 2230 ft.

Harper & Turner and Phillips 1 Wright, NW NW SW, 17-9n-11e, Hughes. DST 3 MMCF gas PD. Gilcrease, 2480-2510 ft.

Sohio 1 Purtle, SE SE NE, 23-1-2, Murray. 15 B 16° oil. 1545-64 ft.

Magnolia 1 Lacy, C SE NW, 5-4n-3w, Garvin. 70 BOPH, 1st Bromide, 9731 ft.

Sinclair Prairie 1 Sparkman, C SE NE, 36-5n-3w. 1 hr DST 250 ft oil & gas. 7009-47 ft.

Superior 1 Harris, NE NE NW, 26-5n-4w, McClain. 17 hr DST 460 B 46.8° oil. Bromide, 10,790-892 ft.

Sinclair Prairie 1 McDaniel, C SE SE, 35-5n-4w, McClain. 5½ hr DST 140 B 46.5° oil & 2316 MCF gas PD. 10,309-49 ft.

● **INDIANA.** Busick & Jones 1 Gazer, NE NE, 6-6s-3w, Perry. 2MMCF gas, Jackson, 508-16 ft.

● **CALIFORNIA.** Independent Exploration 11 Cymric, 21-29s-21e, Salt Creek field, Kern. 1080 B 38.2° oil on 30-min test. Oceanic sand.

Shell well, 12-3s-14w, I mi nw Athens field, Los Angeles. Swb 60 B oil, 8882-9255 ft.

● **MICHIGAN.** Pure 1 State-Beaver, W½ SW NW, 17-25n-4w, Roscommon. Show oil & gas, Monroe, 4020-35 ft.

Muskegon Dev. 1 Bauher, NE SE SW, 24-10n-4w, Gratiot. Measured 400 MCF gas Michigan Stray sand, 988 ft.

● **OHIO.** John Morrow et al on Phoebe R. Seyerle tract, SE SW, Sec 19, Muskingum. 2050 MCF gas, Clinton, 4090-4112 ft.

● **MONTANA.** Sinclair Wyoming 1 Wilkins, NW SW NW, 28-9s-23e, Carbon. 5 MMCF gas, Tensleep, 5912 ft. DST 315 ft oil Frontier, 3425-76 ft. 3212 MCF gas in 40-min, Dakota, 4382 ft.

● **ILLINOIS.** Gilliam Drlg. 1 Berta Ebe, NE NE NW, 14-2n-4e, Marion. DST 1400 ft oil, McClosky, 2754-61 ft; DST 1440 ft gas, 30 ft oil. St. Louis, 2874-84.

Leo V. Horton 1 Wasyl Kokorudz, SW SE NE, 21-6n-2w, Bond. Pump 70 BOPD Trenton 3151-67 ft.

Leo Horton 1 Estoecklin, SW SE SE, 16-6n-2w, Bond. Swb 75 B oil. Trenton, 3160-75 ft.

Joe Reznik 1 Glover NE NE NW 24-7s-9e E. Herold pool Gallatin. IP pumped 195 BOPD Aux Vases 2924-39 ft. New pay.

● **KANSAS.** Lowell Drlg. & Bud Dozier, 1 Hays, NE NE SE, 28-9-18w, Rook. 30 BOPH 31°, Lansing 3405-13 ft.

Continental 1 Gilbert, NE NE SE 6-9s-18w, Rook. 150 ft oil PH Arbuckle 3487-93 ft.

Sinclair Prairie 3 Stuckey, NE NE SE, 28-20-3w, Voshell pool, McPherson. 800 BOPD. 3404 ft. New deep pay.

Mid-Plains & Veeder Supply 1 Reidy, NE NW NW, 15-32-7e, Cowley. 25 BOPD Bartlesville, 2833 ft.

R. E. Youker 1 Henke, SW SE SW 33-18-4e, Marion. 25 BOPD Mississippian, 2442 ft.

Bay 1 Sara Smith, 12-21-12w, Pawnee. Est. 450 BOPD.

Phillips 1 Newkirk, SE NE NW, 11-18-7w, Rice. Pump 58 BOPD Lansing, 3065 ft.

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Interior of an Electric Pilot truck showing the instruments which enable Dowell Engineers to "look" into the bottom of a well.

Dowell's Water Locator finds points of water entry

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The object of Dowell's Water Locator—one of the Electric Pilot Services—is to give a positive and accurate indication of the points of water intrusion in wells. The method employs the latest electro-chemical apparatus and techniques, and has an impressive record of success.

Dowell Plastic Service provides a modern, effective method of controlling water-oil ratios after the points of water encroachment have been found. The liquid plastics used are applied by either bailer or squeeze techniques and change to *impervious solids* to form an excellent seal.

Ask the nearest Dowell station for your free copy of the new, illustrated booklet describing all of the "Electric Pilot Services." Inquire also about other Plastic applications, Selective Acidizing and Chemical Scale Removal Service for heat exchange equipment. Bulk materials: Jelflake, Paraffin Solvents, Inhibited Hydrochloric Acid.

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pipeline developments

● **HOPE TO EXPAND FACILITIES.** Hope Natural Gas Company plans to construct and operate natural gas facilities in West Virginia so that it can receive an additional 50,000,000 cu ft of gas a day, increasing to 165,000,000 cu ft per day Hope's capacity to take gas from Tennessee Gas and Transmission Company. The cost of the facilities has been estimated at $3,004,507.

Facilities include installation of four 1000-hp compressor units together with auxiliary equipment and building at its Cornwall compressor station, 31 miles of 16-in. loop line paralleling an existing line and commencing in Gilmer County, West Virginia, and extending to a point about 16 miles south of Hastings compressor station, and a booster station aggregating 6000 hp in Doddridge County.

● **HOOK UP WITH INCH LINES.** United Natural Gas Company will construct approximately 71 miles of 20-in. natural gas pipe line in Pennsylvania for the purpose of transporting a supply of gas from the Big and Little Big Inch Lines. The gas pipe line will extend from the south end of United's 12-in. line in Beaver County to a connection with the Big and Little Big Inch Lines in Greene County.

Evidence introduced at a public hearing held recently in Washington indicated that the company is in need of additional gas supplies to replace depleting local sources of supply and to enable it to meet present and future requirements of its customers.

● **CENTRAL KENTUCKY ADDS GAS LINE.** Central Kentucky Natural Gas Company has been temporarily authorized by the Federal Power Commission to construct and operate facilities to deliver additional quantities of natural gas to meet estimated future peak day requirements particularly for the coming winter season. The company has estimated the cost of the facilities at $1,933,000.

Facilities authorized include 23.2 miles of 24-in. natural gas pipe line extending from near Foster, Kentucky, to a point on the Ohio River near Brent, Kentucky, and multiple crossings of the Ohio River to connect with pipe lines of the Cincinnati company. Central Kentucky was also authorized to construct a new measuring station at Cold Spring, Kentucky.

● **NEW YORK FACILITIES TO BE ENLARGED.** New York State Natural Gas Corporation has been authorized by the FPC to construct during 1947 and 1948 facilities to increase the capacity of its transmission and storage systems to take additional quantities of natural gas from the Big and Little Big Inch lines and from Hope Natural Gas Company. The overall capital cost of the facilities was estimated at $5,342,366.

Construction to be completed by December 1, 1947, in the State of Pennsylvania include a continuous 90-mile loop line to parallel existing lines extending from a point in Armstrong County to a point in McKean County. This line would consist of 35 miles of 12¾-in. pipe and 55 miles of 14-in. pipe. Also to be completed is the installation of three 300-hp and three 600-hp compressors at the Boom compressor station in Tioga County. This construction was proposed to enable New York State Natural to take 90,000,000 cu ft of gas daily from the Inch lines and Hope Natural.

The remainder of the proposed facilities, to be completed and placed in operation by December 1, 1948, is intended to enable New York State Natural to take deliveries of 110,000,000 cu ft daily. The second group of facilities authorized included construction of a continuation of the looping begun in 1947 and would consist of 24.5 miles of 16-in. loop line extending to a point in Westmoreland County, 21 miles of 14-in. loop line extending northward to a point in McKean County, and 13.4 miles of 16-in. line to connect the north end of an existing line in Potter County with the south end of a line in Potter County.

● **TO SHIP PROPANE BY TANKER.** Plans for the transportation of propane fuel by ship have been announced by the Warren Petroleum Corporation. The initial trip is scheduled for next fall. The ship, the S. S. Natalie Warren, now being converted to a specialized tanker at Beaumont, Texas, will carry 1,300,000 gal of liquid propane per trip, and will make two trips per month from Houston, Texas, to the New York area.

When reduced to commercial gas, this will mean an additional supply of 400,000,000 cu ft per month for New York and vicinity, or enough to supply 285,000 homes and apartments. Propane has never been transported by ship before in such quantities, but has been carried in railroad tank cars. The ship will carry the equivalent of 280 tank cars per month.

● **TWO SMALL LINES PLANNED.** The Anchor Gasoline Company, Tulsa, Oklahoma, announced that it will build a pipe line from Church Point, Louisiana, to Eola, Louisiana, 35 miles away. and remodel a present gasoline processing plant. Cost of the pipe line was estimated at $325,000 and the remodeling at $125,000. The company hopes to have the work completed within four to six months. The pipe line will move an estimated 10,000,000 additional cu ft of gas daily to the Eola plant where it will be used for repressuring oil wells. After the gas is used for repressuring, the residue will be sold to the Southern Carbon Company, Monroe, Louisiana, for carbon black purposes, at the rate of 7,000,000 cu ft daily.

Interstate Oil Pipe Line Company is planning to build an extension of its pipe line system from Oklahoma City into the Katie-Maysville area of Garvin county, Oklahoma, company officials have announced. To be approximately 50 miles long, the new line will provide improved pipe line transportation facilities for the rapidly growing production in that area. Final plans and specifications for the proposed line are now being prepared.

● **FIRST LPG TANKER IN OPERATION.** The first tanker to be equipped to carry high pressure liquefied petroleum gas in bulk is enroute to Rio De Janeiro with a cargo of 100,000 gal of propane, Standard Oil Company (New Jersey) announced. The vessel is the Esso Sao Paulo, a 16,000-ton tanker that was converted to carry the product to provide fuel for sections of Brazil. Eventually, Jersey Standard officials said, the Esso Sao Paulo will be one of a small fleet carrying propane to Latin America. The Esso Avilla, now being reconstructed into a propane carrier, will soon be ready to transport liquefied gas to Venezuela, Central American nations, and Caribbean ports.

● **PIPE LINE AIR UNIT ORGANIZED.** An air patrol of the Interstate Oil Pipe Line Company is scheduled to begin operations September 1. It will fly inspection runs on pipe lines in Oklahoma, Arkansas, Louisiana, and Mississippi, as well as a line from Glennpool, in Creek County, to Wood River, Illinois.

The aviation unit was formed recently to patrol main trunk line systems of the company and lines of the Ajax Pipe Line Corporation. Comprising three planes, the unit is headed by F. T. Piphin.

● **U. S. LEADS WORLD IN TANKERS.** A National Petroleum Council survey reveals that the American tanker fleet numbers 795 vessels and is the largest, fastest, and most modern in the world. The United States possesses 59 per cent of the world's 1,898 tankers.

Great Britain has 17 per cent of the world's tankers, and Norway 9.5 per cent. In September, 1939, Great Britain had 28.2 per cent, the United States 23.9 per cent, and Norway 19.5 per cent.

The council, predicting extreme oil and gas shortages next winter unless production of tank cars is greatly accelerated, asked the government to set aside 18,000 tons of steel monthly for the car-building industry. The steel would be used for construction of cars for petroleum products. Unless car production is stepped up the shortages will be "much worse than heretofore experienced," the council said.

Cook Graphitic Iron Plain Rings feature: Excess carbon in the form of graphite flakes to ease the ring over dry spots in the cylinder—Porosity to facilitate spreading of lubrication—Rapid work-hardening ability to minimize friction, prolong life—Freedom from wear-inducing, steel-like inclusions (carbides).

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In Cook Rings a special material of Cook's own development—Cook Graphitic Iron—is used. This exclusive material has never been duplicated, even though many attempts have been made. It has many unorthodox characteristics by the standards usually followed. Yet for 25 years the claim has been made that it gives the ring longer life and restricts cylinder wear. This claim is repeated here, because test after test in both field and laboratory engines has proven this indisputable fact.

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refining and natural gasoline activities

● **JOINT NATURAL GASOLINE PROJECT.** Sixteen Louisiana oil producers have joined in a modern project to prevent waste of natural gas in the Delhi, West Delhi, and Big Creek oil fields, it was disclosed recently by James E. Pew, manager of the Natural Gas and Natural Gasoline Division of Sun Oil Company. The 16, in one of the first cooperative natural gasoline extraction ventures in the industry, have become part owners of a plant being constructed under the supervision of Sun Oil Company. The Petroleum Engineering Company, Houston, is the builder.

The plant will process approximately 17,000,000 cu ft per day of oil well residue (casinghead gas). Under construction on a 40-acre site in Richland Parish, it will extract 70,000 gal per day of liquid hydrocarbons, including propane, butane, and natural gasoline.

After the liquid products have been extracted from the oil well residue the remaining dry gas will be piped to a connection with a natural gas pipe line company and sold as fuel. Approximately 80 per cent of the producers in the three fields have agreed to join in ownership and operation of the plant. Each company engaged in the venture will own an interest in the plant equivalent to the percentage of ownership held in the producing area. Each company will produce and sell its own share of the natural gasoline and other products recovered.

Sun Oil Company and C. H. Murphy, Jr., jointly own approximately 64 per cent of the producing acreage. Sun has been designated as operator and will have charge of the construction, operation, and maintenance of the plant.

● **REVISE SUN TOLEDO UNIT.** The catalyst change at Sun Oil Company's Houdry fixed-bed catalytic cracking unit, Toledo, Ohio, will be under the supervision of Catalytic Construction Company. Workmen will complete operations on the 12-case unit, which is equipped with the new tube design, the last of August. Six cases will be worked on at one time, while the other six remain on stream.

Catalytic Construction crews have been active at Sun's Toledo refinery since June, 1946, on work that included catalyst change on the Houdry fixed-bed unit, construction of a kerosine sweetening unit, a propane plant, a dry gas purification unit, a boiler house, and, currently, the revamping of Sun's existing gas plant.

● **LUBRICATING OIL PILOT PLANT.** The Socony-Vacuum Oil Company, Inc., has introduced a new lubricating oil pilot plant which the company's research experts described as "the only one of its kind in existence." It is a part of the Socony-Vacuum Research and Development Laboratories, occupying a separate building in which practically every function of lubricating oil manufacture is brought together under a single roof.

The pilot plant is essentially a small lubricating oil refinery, which is capable of manufacturing 200 gal of finished oil per day. It was developed and constructed to produce experimental oils in sufficient quantities to support realistic test programs in the field in the types of equipment that the lubricants are designed to serve.

In addition to manufacturing lubricating oils in pilot-plant quantities, the new Socony-Vacuum plant enables intensive studies of various types of crude oil, thus permitting selection of the best basic crudes for all lubricating tasks. Another feature of the pilot plant is the facilities it provides for developing new-type lubricants.

The pilot plant consists of a building 78 ft wide, 228 ft long, and 30 ft high to house the various refining units. In addition, a nearby tank farm for exclusive use of the pilot plant contains 24 tanks, which range in size from 500 to 15,000 gal, used for storage of crude oil, fractions of crude oil, finished oils, and solvents employed in the refining process.

● **TO CONVERT PLANT TO SYNTHETIC FUELS.** Conversion of the Missouri Ordnance Works near Louisiana, Missouri, from synthetic ammonia to synthetic liquid fuels production, started late in 1945 by the Bureau of Mines, again is under way following an extended delay caused when the plant was taken back by the War Department for emergency production of ammonia for fertilizers, Secretary of the Interior J. A. Krug reported. The Bureau recently took over the $17,500,000 plant.

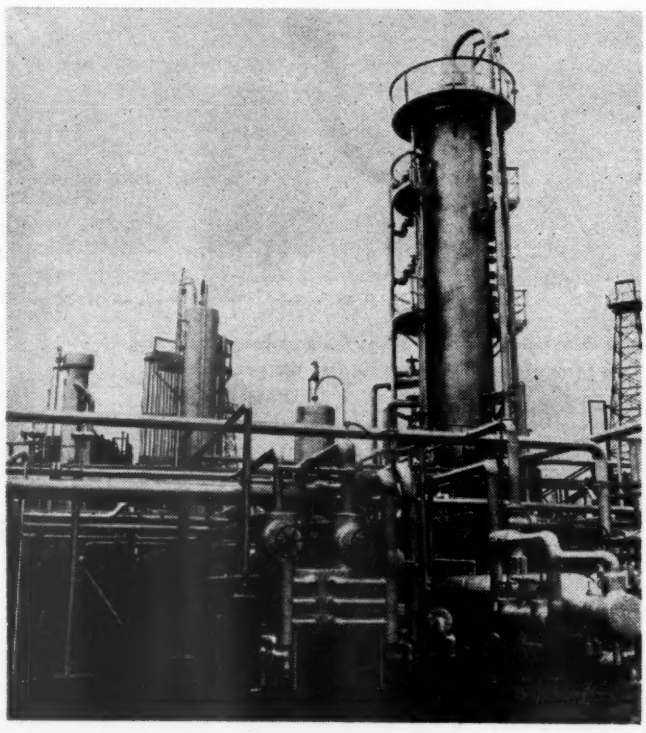
Design work continued during the year at Torrance, which is the headquarters for Bechtel Corporation, which holds a $6,780,000 contract for engineering, design, and construction necessary under the conversion program. Equipment, grading, and housing subcontracts totaling approximately $4,000,000 have been placed. The construction schedule calls for the Missouri plant to be producing gasoline and oil from coal and lignite by June 30, 1948.

New structures to be erected in an area just south of the present ordnance plant will include coal and paste preparation buildings, a compressor house, four pump houses, two control houses, coal hydrogenation stalls, an oxygen unit, a shop, a change house, and several small buildings. Many of the ordnance plant's existing facilities and equipment can be used with little modification by the Bureau of Mines, saving several million dollars in construction costs.

● **DE-ASPHALTING UNIT COMPLETED.** The Wax Division of the Petrolite Corporation, Ltd., has announced the completion of a new propane de-asphalting unit at its Kilgore, Texas, refinery. The new unit, licensed by the M. W. Kellogg Company and constructed by the Koch Engineering Company of Wichita, Kansas, is of the latest design and will greatly augment Petrolite's production of high melting point microcrystalline waxes.

The Petrolite Wax Division is under the direction of R. F. Scivally, general manager, with headquarters at the Kilgore refinery. E. C. Livingston is refinery superintendent and A. W. Marshall is chief chemist and director of research.

Petrolite plant for propane de-asphalting.



P 111.7

THE Petroleum Engineer

AUGUST, 1947

Oil prospecting in Alaska

By K. MARSHALL FAGIN, *Field Editor*

EXCLUSIVE

BY THE light of this summer's midnight sun, the U. S. Navy is continuing its carefully planned search for oil in that part of the tundra-covered wastelands of North Alaska known as Naval Petroleum Reserve No. 4. This 35,000 sq mile area, which was set aside as a reserve by President Harding in 1923, has been recognized as a potential oil province by most of the few geologists who have visited it since the turn of the century.

It was not until 1943, however, that serious plans were made to attempt a full scale evaluation of its oil-producing prospects. These plans were stimulated by a dangerous shortage of crude oil supplies on the West Coast for carrying out our gigantic naval program against Japan in the Western Pacific during World War II. Modern airplanes, radio, amphibious track-type vehicles, and oil prospecting equipment gave the plans practical significance as a means of finding and developing oil fields under the frozen earth of Northern Alaska.

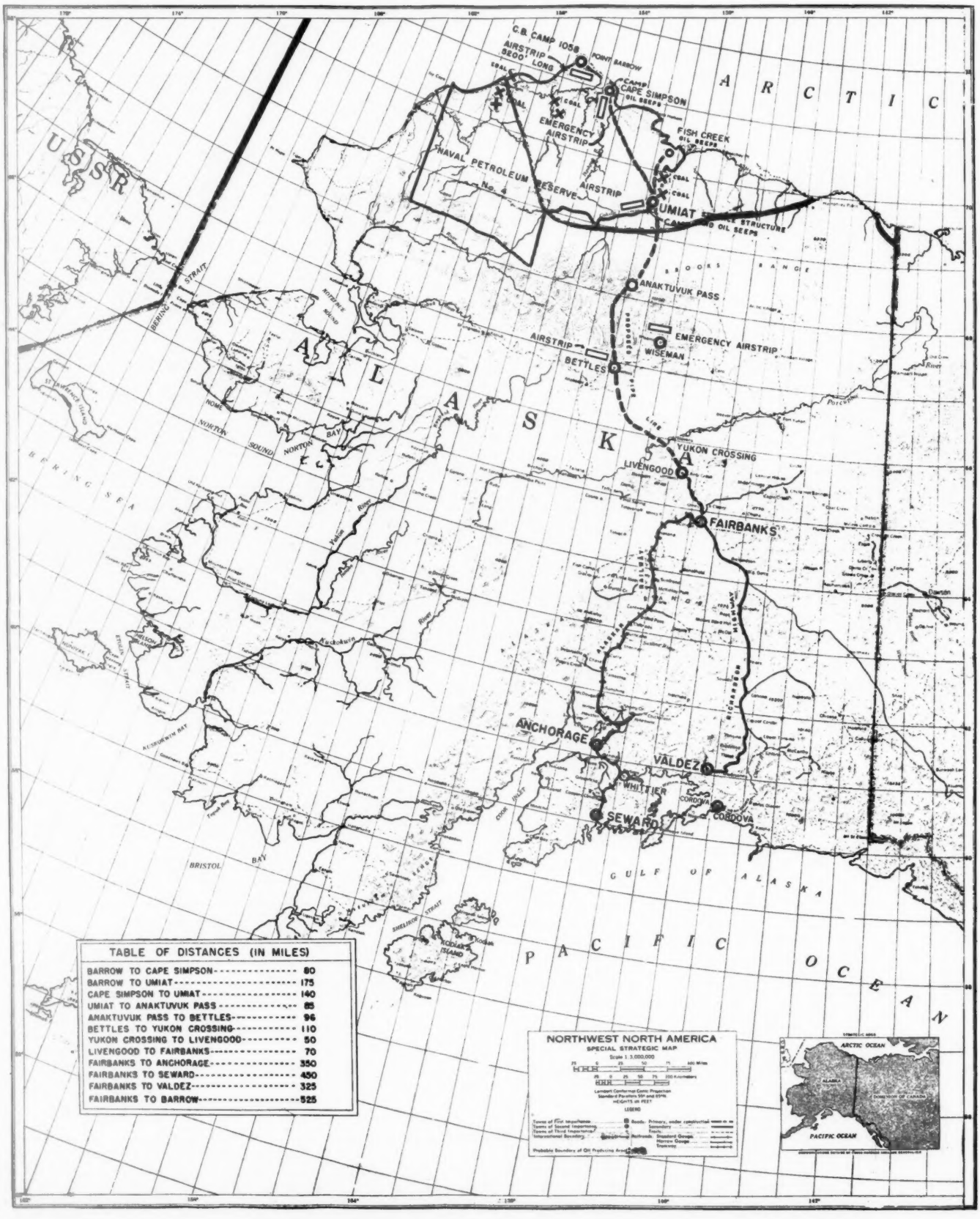
Fig. 1 shows the outline of Naval Petroleum Reserve No. 4, which is between the Brooks mountain range and the Arctic Ocean. A dotted line shows the probable southern extent of oil production in this large sedimentary geosynclinal area, known as the Barrow Basin. Geological surveys and wells drilled thus far indicate that oil may be found in the eastern two-thirds of the reserve, and in large areas east of the present boundary of the reserve. All northern Alaska, including the area outside the reserve, is closed to public oil prospecting by the Department of the Interior's Public Land Order No. 82.

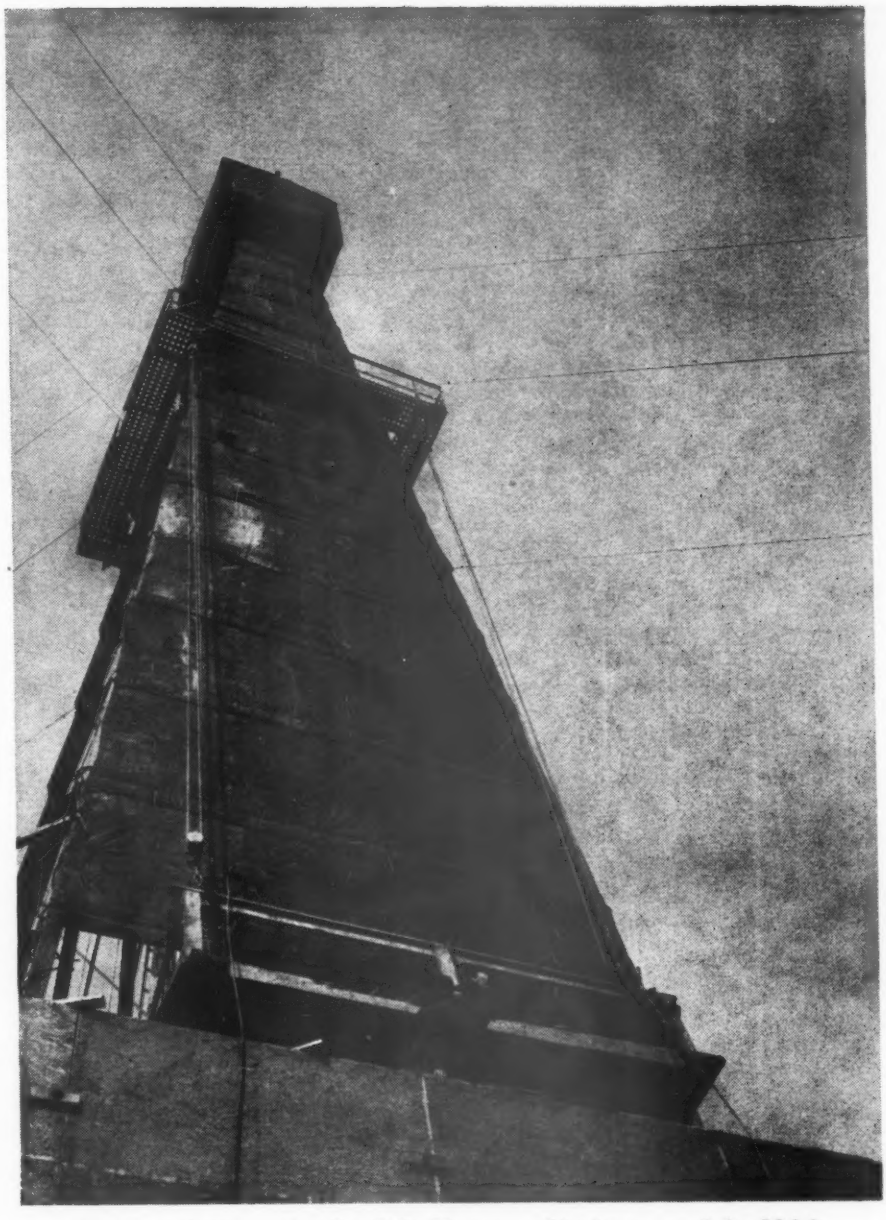
● **First oil drilling equipment landed in 1944.** The first full-scale oil prospecting expedition was landed by the U. S. Navy's Seabees at Point Barrow in the summer of 1944. Modern drilling equipment and all the material and supplies necessary to construct air strips, warehouses, and living quarters were brought in by the vessels that made this historic voyage under the threatening shadow of the Arctic ice pack.

At Ladd Field, Fairbanks, Alaska, the party en route to the Naval Reserve is met by General Everest, U. S. Army Commander of the Yukon sector, and others. Shown are: C. O. Willson, editor of *Oil and Gas Journal*; Bart W. Gillespie, project manager for Arctic Contractors; General Everest; Commodore William G. Greenman, director, U. S. Naval Petroleum Reserves; Commander P. W. Roberts, officer-in-charge of construction for Naval Reserve No. 4; K. Marshall Fagin, field editor of *The Petroleum Engineer*; Walter A. English, geologist and chief technical advisor; Col. Whatnee, Commandant, Ladd Field.

Geological surveys being conducted on the reserve by the Navy and the U. S. Geological Survey in the spring and summer of 1944 indicated a large anticlinal structure near the previously discovered oil seeps at Umiat, about 180 miles southeast of Barrow. After constructing a base and air strip at Point Barrow in the fall of 1944, "cat" trains were loaded with a drilling rig, pipe, drums of fuel oil, and all the other supplies needed to drill the first well, Umiat

FIG. 1. Modern airplanes with radio aids have brought Naval Petroleum Reserve No. 4, 500 miles north of Fairbanks, within six hours distance of the Naval Base at Kodiak, more than 1000 miles south. The 35,000-sq mile reserve set aside by President Harding in 1923 is now being actively prospected for the third consecutive year. It is bounded on the southeast by the Colville river, which flows east along the north side the Brooks range foothills to Umiat and thence North to the Arctic ocean. The western third of the reserve is believed unlikely for oil production. An effort is being made to exchange this portion of the reserve for more probable oil-producing territory south and east of Umiat (indicated by the heavy line that outlines what is known as the Barrow basin). Two wells are now drilling on the reserve.





Workmen fasten an insulated double canvas blanket around the 136-ft. derrick of Cape Simpson No. 1, the world's farthest north deep test.

No. 1. These trains included "wanigans," 8 by 20-ft huts on sleds, for cooking, eating, and sleeping.

These trains embarked for Umiat in the frigid darkness of the following winter when the ice on the countless lakes had frozen to a thickness sufficient to prevent the trains from breaking through. Small planes surveyed the route during the twilight hours and dropped flags to guide the "weasels," amphibious jeeps on tracks, that scouted the trails ahead of the cat trains.

● **First well, Umiat No. 1, begun in 1945.** A sub-base camp was constructed at Umiat in the valley of the Colville river, and the drilling rig was erected on the crest of a high scarp about 5 miles northwest. The well was spudded on June 22, 1945, and drilled to a depth of 1816 ft, where it was shut down on September 16. Several encouraging shows of oil were found in the Upper Cretaceous sandstones between surface and 1816 ft.

Some time after Japan surrendered, the oil-prospecting operations on the reserve by the Seabees were terminated. Hoover, Curtice, and Ruby, Inc., of New York, were the principal contractors selected by the Navy to carry out the exploration program for Naval Petroleum Reserve No. 4 under the direction of Commodore William G. Greenman, Director of Naval Petroleum Reserves, Washington, D. C.

Commander P. W. Roberts, U. S. Navy, is the officer-in-charge of construction for operations in Alaska. Headquarters at Fairbanks include offices for the Navy, the Arctic Contractors, the United Geophysical Company, and the U. S. Geological Survey. Bart W. Gillespie is the project manager for Arctic Contractors, which handles the drilling operations for the Navy through Hoover, Curtice, and Ruby.

● **Present activities guided by an operating committee.** Policies and plans in connection with the Navy's exploration for oil in Naval Petroleum Reserve No. 4 are developed by an operating committee that was established by the under-secretary of the Navy. Most of the plans have been established at the annual November meetings of the operating committee in Washington, D. C. As director of Naval Petroleum Reserves, Commodore Greenman is chairman of this committee, which at present includes the following: Colonel Ottmar F. Kotick, Army of the United States, Army-Navy Petroleum Board; Dr. William E. Wrather, Director, U. S. Geological Survey; Lt. Commander Fred Cooke, (CEC), U. S. Navy, Bureau of Yards and Docks; Lewis W. MacNaughton, DeGolyer and MacNaughton, Dallas, Texas; A. A. Curtice, vice president of Hoover, Curtice, and Ruby, and Walter A. English, geologist, Los Angeles, chief technical advisor.

Under the plans and policies established by the operating committee, drilling was resumed at Umiat No. 1 on June 7, 1946. Several more oil-bearing sandstones were cored and tested before the well was abandoned in the Upper Cretaceous at a total depth of 6005 ft on October 5, but commercial oil production was not obtained.

● **Oil discovered in Umiat Core Test No. 1.** Seismograph and geological work during 1946 confirmed the earlier indications of a major closed structure at Umiat. A core test was begun on November 15, 1946, near the crest of the structure as determined by the seismograph work, which is about six miles east of Umiat No. 1. A little oil was found in this well on November 29, but it was temporarily abandoned in permafrost (frozen earth) at a depth of 572 ft on December 26. It is now awaiting installation of equipment for a pumping test of an oil sand found at a depth of 248 ft. Whether or not it is of commercial importance remains to be seen.

Umiat Core Test No. 1 prompted plans for Umiat No. 2, which is now being drilled about one-quarter mile south of the core test. It was spudded on June 26 and was testing an oil sand at 345 ft on July 10. Umiat No. 2 is projected to a depth of 3000 ft, inasmuch as all the potential producing horizons in Umiat No. 1 were found above this depth.

● **A 6000-ft test being drilled at Cape Simpson No. 1.** The other rotary rig in operation on the reserve this summer is drilling a test well, Cape Simpson No. 1, about 40 miles southeast of Point Barrow. It was spudded on June 14, 1947, and was coring at a depth of 593 ft on July 10. It is projected to a depth of 6000 ft, or more.

Several large oil seeps in this area have been known and used by the Eskimos for many years. Seismograph work during 1946 indicated a structure with a small closure. Surface geology is difficult, if not impossible, in this area, because of the low topographical relief of the Arctic coastal plain and the lack of significant outcrops.

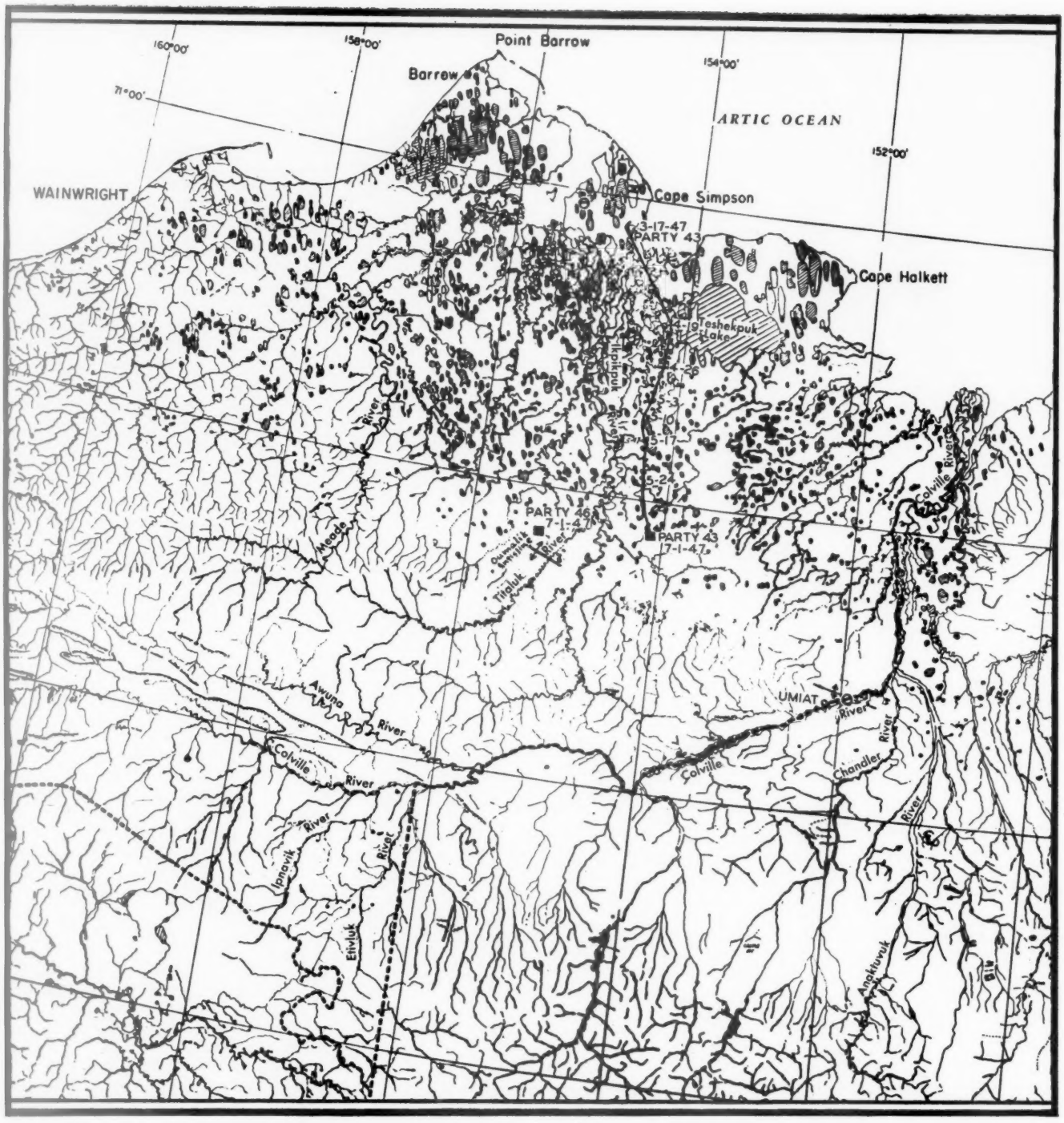


FIG. 2. Map compiled from trimetrogon photography by USGS for Army Air Forces shows many of the lakes and meandering streams covering the Arctic coastal plain.

● **Several other core tests drilled this year.** Three other core tests for geological data have been drilled in other parts of the reserve this spring, and another one has recently been spudded. Sentinel Hill Core Test No. 1, about 70 miles southeast of Point Barrow near Smith Bay, was begun on January 26, 1947, and abandoned at a depth of 1180 ft on March 23.

Skull Cliff Core Test No. 1, which was about 40 miles southwest of Point Barrow near the Arctic coast, was begun on February 2, 1947, and abandoned at a depth of 779 ft on March 17. Barrow Core Test No. 1, near Point Barrow, was spudded on March 29, 1947, and abandoned at a depth of 1442 ft on April 29.

Another core test for geological data was spudded about July 7, 1947, on the Oumalik structure about 115 miles south of Point Barrow. It is near the present camp of seismograph party No. 46.

● **Two reflection seismograph parties now working.** Seismograph party No. 46 is now profiling the large Oumalik anticline at one-mile intervals. The party began reflection seismograph work at the Ikpikpuk River on March 28, 1947. The Oumalik structure was indicated by aerial magnetometer work during the previous season's work in the Ikpikpuk area. The present area being detailed by party No. 46 is west of the Titaluk River as shown on Fig. 2.

Seismograph party No. 43 is now continuing southward on a reflection seismograph line that it began in the Smith Bay area on March 17, 1947. This party has traversed about 90 miles to its present position east of the Ikpikpuk River. It is about 30 miles east of party No. 46 as shown on Fig. 2. It is planned to combine party No. 43 with party No. 46, so as to complete the detailing of the Oumalik structure this year.

● **Airborne gravitymeter party making rapid progress.** A flying gravitymeter party has been used since March, 1947, for rapid reconnaissance of the gravity

Commodore Greenman, right, and Bart Gillespie, center, enjoy a joke at Umiat No. 2 with Glen Ruby, left. Leslie Riggins, geologist, is at extreme right.

picture of the reserve. This is believed to be the first time that an airplane has been used to transport a gravitymeter from station to station. It is certainly the first time that such a party has been flown in an airplane equipped with skis, and the first time such a party has operated so far north.

The plane, an 85-hp Cessna, is now equipped with pontoons for landing in the many lakes that dot the reserve. Forty to seventy per cent of the area of the northern part of the reserve is covered with lakes. Most of these are now free of ice. Six or seven stations about 10 miles apart can be surveyed each day by this airborne gravitymeter party. The most difficult problem is determining the elevation of the stations, but this is being done satisfactorily considering the rapid and preliminary nature of the survey.

It is estimated that two-thirds of the reserve will be surveyed by the flying gravitymeter party this year. The party is operated by three men, but only two are carried aloft at one time. The plane has performed satisfactorily in all kinds of weather. It is operated every day that the pilot has enough visibility to make the necessary contact landings. So far, Arctic ground fogs have kept the plane grounded about 30 per cent of the time.

● **USGS has four ground parties and one airborne party in the area.** Three U. S. Geological Survey parties of four to five men each are now completing reconnaissance of surface outcrops along the main rivers that flow northward across the reserve. Party No. 1 is working along the Colville River west of Umiat. It will continue westward to the coast of the Arctic Ocean. Party No. 2 is working along the Kigalik and Awana rivers. Party No. 3 is going down the Utukok River to the Arctic coast.

A fourth USGS party is working isolated outcrops between the rivers on the south part of the reserve with a Cub plane, which is now equipped with pontoons. A fifth USGS party is working outcrops down the Shaviovik and Canning rivers, which are outside Naval Petroleum Reserve No. 4 and about 120 miles east of Umiat.

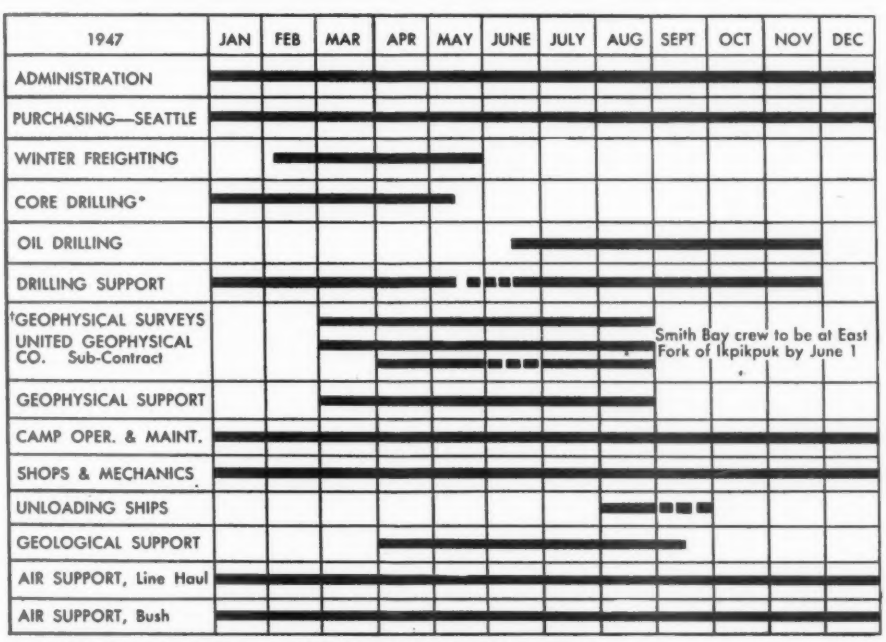
Geological work was begun by the USGS in a limited way as early as 1895. Later, the work of 25 parties in 1923 to 1925 resulted in the location of most of the oil and gas seepages known today. The work by the USGS was revived in 1944 by a party that worked along the Colville River near Umiat during the summer season. In 1945, three parties worked outcrops along the headwaters of some of the rivers that rise in the Brooks mountains. Five parties worked in the area of the reserve in 1946.

Although the Navy's operations in this huge reserve are isolated by hundreds of miles of treeless Arctic coastal plains, they are closely knit together by regular airline schedules and nightly radio talks with Barrow or Umiat headquarters. Radio messages may be relayed at any time to reserve headquarters at Fairbanks, which is 525 miles south of Barrow. A mileage table is shown in Fig. 1.

● **Operations have to be planned a year in advance.** This year's schedule of operations is shown in Fig. 3. It is a graphic picture of the plans that were finally approved on December 9, 1946, by Bart W. Gillespie, project manager of Arctic Contractors, and Commander P. W. Roberts, officer-in-charge of construction. The schedule for 1947 operations reflects a great deal of earlier planning by the operating committee, Commodore Greenman, and all those who had to see that the bulk of the material and supplies necessary to carry out this schedule would be available or shipped to Point Barrow on the ships that landed in August, 1946.

Airplanes have flown in many heavy items of equipment and supply at various times such as hundreds of drums of fuel oil and gasoline, a string of drill pipe,

FIG. 3. Schedule of operations for 1947 as it was approved December 9, 1946, by Gillespie and Commander Roberts. It represents earlier planning by Commodore Greenman, the operating committee, and others.



*CORE TEST UMIAT NO. 1 STARTED NOV. 1946

†SEISMOGRAPH, EAST FORK IKPIKPUK
SEISMOGRAPH, SMITH BAY
GRAVITIMETER, AIR-BORNE

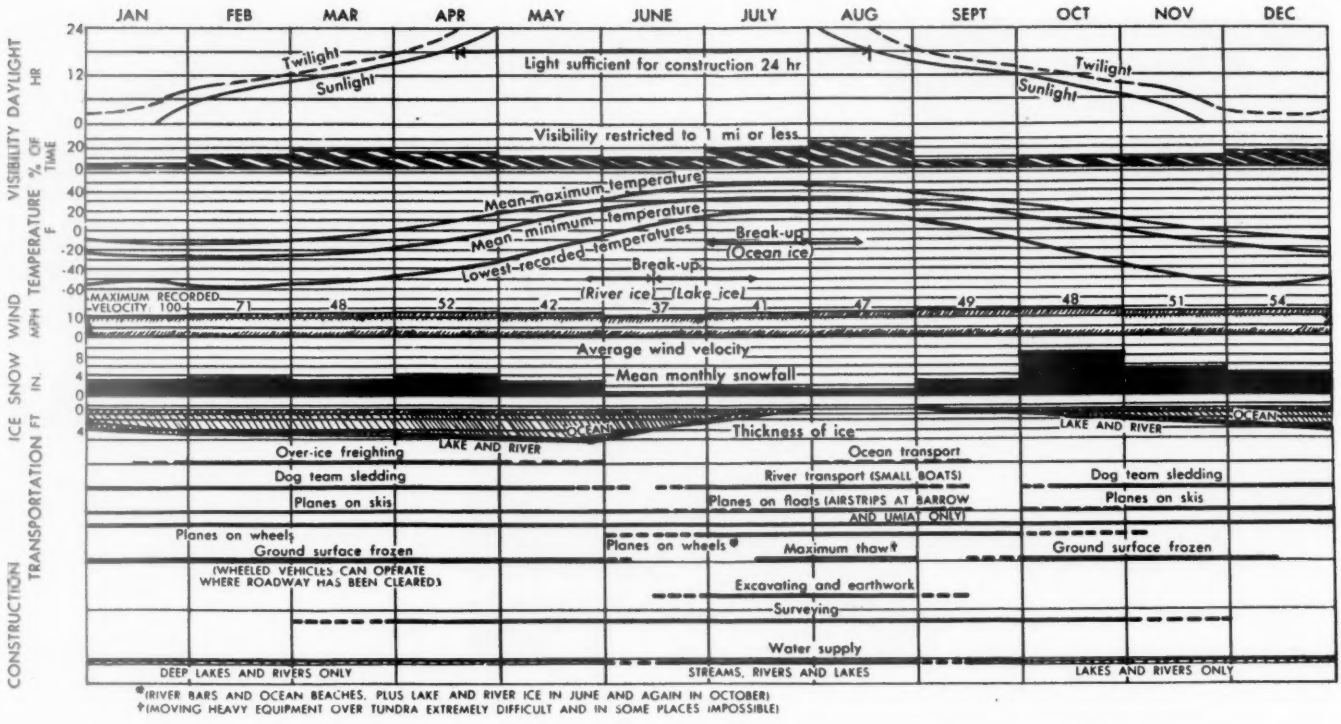
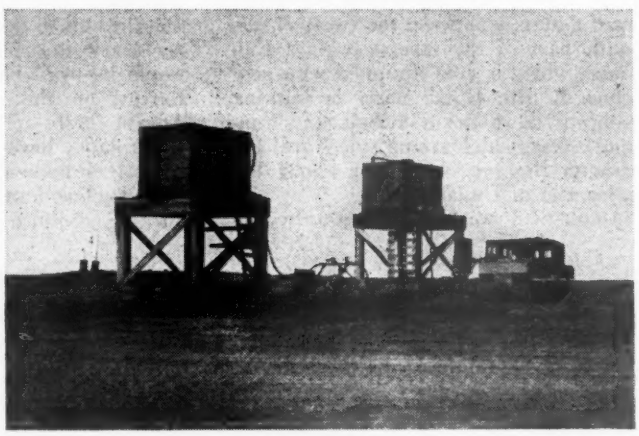


FIG. 4. A work feasibility chart used to guide the Navy and its contractors in planning Arctic operations.



An Eskimo fills gasoline tank of a weasel at Point Barrow service station, closest one to the North Pole. Beach No. 4 sign is at left.

All is quiet at midnight in the advanced base camp at Point Barrow. Two large buildings on left are warehouses; smaller ones are quarters for oil searchers.

weasels and jeeps, generators, and thousands of pounds of food.

● **Navy plane flies in 9000 lb of dynamite.** A four-engine Navy cargo plane recently flew a 9000-lb supply of dynamite from Fairbanks to Barrow. About 100,000 lb of dynamite has been flown into the reserve for the seismograph parties this year. An extra supply of certain items like this have to be flown in, but the bulk of the material and supplies are shipped to Barrow and hauled across the reserve by cat trains in the winter.

Although only six kinds of operations are shown to be continuous the year round, experience has proved that oil-well drilling and core test drilling can be pursued throughout the year provided operations are covered and enough fuel oil and heating facilities are available.

● **Chart shows weather conditions and work feasibility.** Although the thermometer in Fairbanks has indicated a maximum record temperature of 99 F, the temperature on the naval reserve in the summer rarely exceeds 60 F. Fig. 4 shows that the mean maximum temperature at Point Barrow is about 45 F, and that the lowest recorded temperature is —58 F. Point Barrow and the reserve are cooled in the summer by the prevailing northeast wind off the Polar ice cap, whereas Fairbanks is sheltered by the Brooks mountain range.

An almost continuous layer or blanket of clouds is carried over the reserve by this Arctic ice cap wind, and, as the clouds often roll in low, visibility is reduced to less than a mile 10 to 20 per cent of the time during seven months of the year (see Fig. 4.) This and the icing conditions that prevail much of the time add greatly to the hazards of air transport. The DC-3's on the linehaul from Fairbanks to Barrow have managed to fly every day, however, with CAA radio ranges and U. S. Weather Bureau aid.

★★★

Hydrocarbon absorption and fractionation process design methods

Part 4. Vapor-Liquid Phase Distribution Calculations

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Hydrocarbon Research, Inc.

EXCLUSIVE

In the previous chapter the phase behavior of hydrocarbon mixtures and petroleum fractions and the operations of vaporization and condensation were discussed. It was shown that the "bubble" point, which corresponds to 0 per cent vapor and saturated liquid, and the "dew" point, which corresponds to 100 per cent vapor and saturated vapor, represent the limits of the coexistence of the two (vapor and liquid) phases. This phenomenon was represented by the phase diagram and the procedure for computing bubble and dew points was demonstrated.

Equations and calculations were also presented for batch differential vaporization. The next subject of interest is continuous equilibrium vaporization, for which equations will be developed and illustrating calculations shown.

CONTINUOUS VAPORIZATION

Continuous vaporization (or condensation) is assumed to take place under such conditions that equilibrium exists between all the vapor and the liquid. The requirements of continuity of operation presuppose a feed and products of constant compositions and rates. This process of vaporization (and condensation) occurs in many places in the refinery. There are single flash and successive flash vaporizations. In single flash vaporization all the vapor formed remains in contact with the liquid during the entire process. In one form of successive flash vaporization the vapor formed at each flashing is removed before the next flashing. If a distillation operation is divided into an infinite number of successive flashes with the removal of small increments of vapor, the result is batch or differential vaporization.

In another form of successive flash vaporization the vapor and liquid are removed continuously and mixed with liquid and vapor, respectively, from other flashes and then reflashed. This type of successive flash vaporization makes up fractionation.

The mechanism of vaporization in a pipe still is that of continuous equilibrium vaporization or flashing. Equilibrium flash vaporization is sometimes called "pipe still" distillation for this reason. The advantage of equilibrium flash vaporization over batch distillation lies in the fact that it is continuous and the carrying effect of the light ends help vaporize the heavier components at a lower temperature than possible in batch distillation. Pipe still distillation is accomplished by heating the charge in a tubular furnace and flashing it into a fractionating tower, where it is separated into the desired products. The flash vaporization of the charge in the fractionating tower usually takes place with enough "over-flash" to accomplish the desired fractionation, i.e., the percentage of the charge vaporized is higher than sum of the percentages of all the "distillate" products from the unit. This "over-flash" supplies the necessary heat to vaporize reflux that must be used to get the required efficiency of fractionation. Heat might be supplied by reboiling the liquid from the bottom plate but this would require temperatures that are too high and thermal decomposition would result. Although the charge is vaporized by single flashing, the fractionation is successive flash vaporization and condensation from plate to plate.

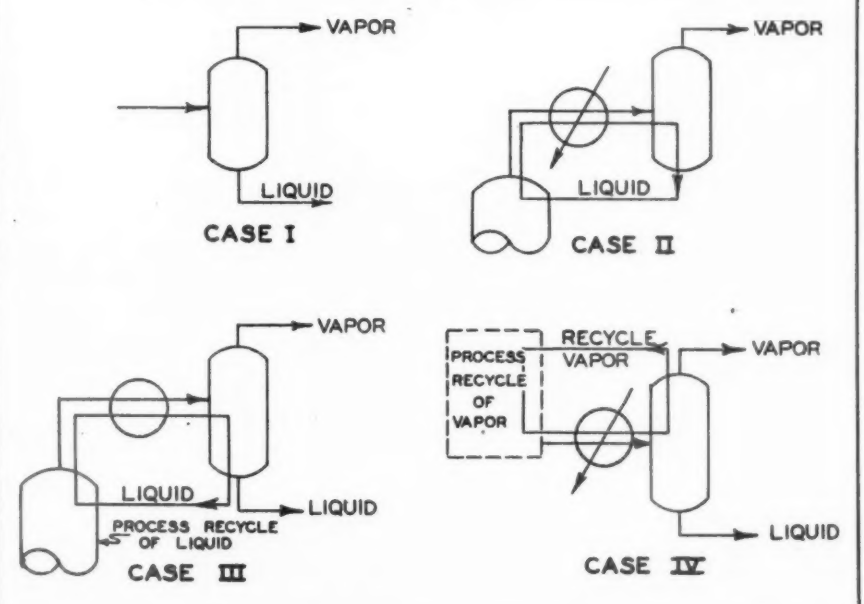
The separation between vapor and liquid that occurs in gas separators and reflux drums is an example of continuous equilibrium partial condensation, which is frequently encountered in various modifications as illustrated by Fig. 22.

Case I on Fig. 22 represents a straight equilibrium separation where all the material entering the separator goes into the gas and liquid products and none of the gas or liquid is recycled. There are many examples of this type of separation in the refinery; e.g. wet gas condensate drums following gas coolers at vapor recovery plants, and overhead separators on towers having closed coil or circulating top tray pump-around reflux systems.

Case II shows the equilibrium separation in a reflux drum where the gas is the only product leaving the system and all the liquid is recycled to the top of the bubble tower as reflux. This type of separation is commonly used on light hydrocarbon fractionating towers such as stabilizers where the net overhead product is propane and lighter and the reflux is a mixture of ethane, propane, and butane but mostly propane.

Case III shows a separation in a system where both gas and liquid are the net products and where a part of the liquid condensate is recycled to the top of the bubble tower as reflux. This type of overhead system is used on stabilizers where a propane-rich liquid stream is

FIG. 22. Four alternate cases of equilibrium separation.



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required. In this system, ethane and lighter is taken off as a gas.

Case IV shows an equilibrium separation in a system where both gas and liquid are the net products and where a part of the gas overhead is recycled through the unit and returned to the separator. An example of this type of separation is the recycle gas separator on catalytic reforming units where the presence of the hydrogen rich recycle gas is necessary for the reaction although it apparently takes no part in the reaction as a net amount of gas is made in the process.

Methods of computing these equilibrium separations will next be developed and it will be shown that the same basic calculation method can be used for all four of these separations. Equations for making component calculations for equilibrium flash vaporization of hydrocarbon mixtures are developed for the above four cases by the application of total and component material balances and the concept of the vapor-liquid phase equilibrium distribution constant. Reference will be made to Fig. 22 in this development.

Case I (Fig. 22) with no gas or liquid recycle is the most straight-forward case of equilibrium separation. All the other cases may be reduced to this case by adding the recycled material to the feed and considering the total products from the separator rather than the net products. The calculation method will first be developed and illustrated for Case I. After that the other cases will be considered.

A total material balance states:

$$F = V + L \quad . \quad . \quad . \quad . \quad . \quad . \quad (20)$$

A component material balance states:

$$Fz = Vy + Lx \quad . \quad . \quad . \quad . \quad . \quad (21)$$

or

$$f = v + l \quad . \quad . \quad . \quad . \quad . \quad . \quad (21A)$$

Equations (21) and (21A), which apply to any one component, express the same relationship differently.

Combining equations (20) and (21) and the definition for the equilibrium constant, $K = y/x$, and solving for y, gives:

$$y = \frac{\left(1+\frac{L}{V}\right)}{\left(1+\frac{L}{KV}\right)} z \quad . \quad . \quad . \quad . \quad . \quad (22)$$

In like manner a similar equation relating x and z is developed.

$$x = \frac{\left(1+\frac{V}{L}\right)}{\left(1+\frac{VK}{L}\right)} z \quad . \quad . \quad . \quad . \quad (22A)$$

By definition $y = v/V$, $x = l/L$, $z = f/F$ and $l/v = \frac{L}{KV}$. Substituting in above equations gives:

$$v = \frac{f}{1+\frac{L}{KV}} = \frac{f}{1+\frac{l}{v}} \quad . \quad . \quad (23)$$

TABLE 1. Flash vaporization calculations *(Example 3)*

	Feed		$K^{140\ F}_{200\ psia}$	Trial 1 Assume $\frac{L}{V}=1.5$		Trial 2 Assume $\frac{L}{V}=1.60$		y	Liquid	
				$\frac{L}{VK}$	$f \div (1+\frac{L}{VK})$	$\frac{L}{VK}$	$f \div (1+\frac{L}{VK})$		l	x
	f	z								
C_2	100	0.25	3.70	0.405	71.2	0.432	69.75	0.453	30.25	0.123
C_3	100	0.25	1.38	1.087	47.9	1.160	46.25	0.300	53.75	0.218
C_4	100	0.25	0.57	2.63	27.6	2.800	26.30	0.171	73.70	0.300
C_5	100	0.25	0.212	7.07	12.4	7.55	11.70	0.076	88.30	0.359
	400	1.00			159.1		154.00	1.000	246.00	1.000
				V=159.1		V=154.0				
				L=400—159.1=240.9		L=400—154=246				
				$\frac{L}{V}=1.514$		$\frac{L}{V}=1.60$ (check)				

TABLE 2. Flash vaporization calculations *(Example 4)*

	Feed		Trial 1 Assume t=120 F			Trial 2 Assume t=125 F			t=125 F			
									Vapor		Liquid	
	f	z	$K^{120\ F}_{200\ psia}$	$\frac{L}{VK}$	$f \div (1+\frac{L}{VK})$	$K^{125\ F}_{200\ psia}$	$\frac{L}{VK}$	$f \div (1+\frac{L}{VK})$	v	y		x
C_2	100	0.25	3.20	0.938	51.5	3.32	0.903	52.5	52.2	0.522	47.8	0.159
C_3	100	0.25	1.17	2.56	28.0	1.22	2.46	28.8	28.6	0.286	71.4	0.239
C_4	100	0.25	0.455	6.6	13.2	0.485	6.2	13.9	13.8	0.138	86.2	0.287
C_5	100	0.25	0.158	19.0	5.0	0.17	17.6	5.4	5.4	0.054	94.6	0.315
	400	1.00			97.7			100.6	100.0	1.000	300.0	1.000
			V=97.7			V=100.6						
			L=400—97.7=302.3			L=400—100.6=299.4						
			$\frac{L}{V}=3.10$			$\frac{L}{V}=2.99$ (check)						

and

$$l = \frac{f}{1+\frac{KV}{L}} = \frac{f}{1+\frac{v}{l}} \quad . \quad (23A)$$

Equations (22A) and (23A) are different forms of equations (22) and (23). These equations may be used to predict the amount of each component of a mixture vaporized or condensed under given pressure and temperature conditions or they may be used to predict the conditions necessary for given quantities of total vapor and liquid. Each computation involves successive approximations.

The procedure to be followed in estimating the equilibrium separation at a given temperature and pressure conditions is as follows:

Step 1: Find values of K for all components in the mixture at the given temperature and pressure.

Step 2: Assume an L/V ratio.

Step 3: At this assumed L/V ratio, compute L/VK for each component.

Step 4: Using these values of $\frac{L}{VK}$ and the given values of f, compute v for each component by means of equation 23.

Step 5: Find V as the sum of v and calculate L/V. If this calculated L/V ratio checks the assumed L/V ratio of step 2, the values of v computed in step 4 are correct.

Step 6: If the calculated L/V ratio does not check the assumed, repeat steps 2, 3, 4, and 5 with different L/V ratios until a check results.

Step 7: Compute *l* for each component by equation (21A).

The following example illustrates this procedure:

Example 3. Find the vapor and liquid for the equilibrium separation of 400 mols of an equal molal mixture of ethane, propane, n-butane, and n-pentane at 140 F and 200 psia. It will be noted that the bubble and dew point of this mixture at 200 psia were found in Part 3 of this series to be 95 F and 197 F, respectively. The solution in Table 1 embodies all of the above seven steps in a single tabulation.

When the L/V ratio and pressure (or temperature) are known and the temperature (or pressure) are to be found, the procedure is similar to the above except that temperatures (or pressures) instead of L/V ratios, must be assumed for each trial.

Example 4. As an example of this type of calculation, the temperature at which the above mixture will be 25 per cent vapor and 75 per cent liquid

$$(L/V = \frac{300}{100} = 3)$$

at 200 psia is computed in Table 2. This last computation is not as frequently occurring as the previous one.

Case II (Fig. 22) shows a liquid-vapor separator operation with all the liquid being recycled. This case could be computed by the same equation and procedure used in Case I if the circulating reflux is considered as a liquid product

and added to the net overhead to obtain the total separator feed. The composition and amount of the reflux are unknown, however, and must be determined by a dew point calculation and a column heat balance. The dew point computation gives the composition of the circulating liquid reflux regardless of its quantity.

Example 5: The dew point computations given in Table 3 show the analogy between Case I and II. Given a net overhead vapor of 154 mols of the same composition as the vapor from the separator in the first example under Case I where the separator pressure was 200 psia and the separator temperature was 140 F, find the separator temperature and composition of the reflux for this Case II operation.

TABLE 3. Case I and II dew points *(Example 5)*

	Net overhead		Assume t=140 F	
	v	y	$K_{200\ psia}^{145\ F}$	x=y/K
C_2	69.75	0.453	3.70	0.123
C_3	46.25	0.300	1.38	0.218
C_4	26.30	0.171	0.57	0.300
C_5	11.70	0.076	0.212	0.359
	154.00	1.000		1.00 (check)

The reflux composition checks the liquid composition in Case I.

Assume 300 mols of reflux and make a Case I type flash vaporization calculation to check above temperature found in Table 3. These calculations are given in Table 4.

$$\frac{L}{V}=\frac{300}{154}=1.95$$

This calculation shows that once the quantity and composition of net vapor overhead is fixed for this type of separation (Case II) the composition of the circulating reflux is determined and its quantity can be set at any amount without affecting compositions of the liquid and vapor or the amount of the vapor.

Case III is a separation involving recycling a part but not all of the equilibrium liquid. This separation can also be computed without knowing the amount of the recirculated reflux, thus reducing to the simple Case I separation.

Example 6. This will be demonstrated by making an equilibrium flash calculation on the net and total feeds to a separator of this kind. Since the net products are the same in all cases, the net feed will be the sum of the products in the Case I 140 F separation, hence the calculation made above for Case I will serve for the net feed flash calculations.

Assume 100 mols of reflux of the same composition as the liquid product for the Case I separation. On the total feed basis the ratio $\frac{L}{V}=\frac{246+100}{154}=2.245$

Table 5 gives the balance of calculations. The vapor composition and amount checks the net feed calculation for the Case I separation at another L/V ratio but with no recycle reflux.

The above calculation shows that the circulating reflux can be neglected in computing the equilibrium flash separation of the net overhead where the circulating reflux is of the same composition as the liquid product.

Case IV shows the separation of liquid and vapor products with the recycle of vapor. It will now be shown that the calculation of this separation is the same as Case I and the recycled gas can be neglected.

Example 7. This will be demonstrated by making an equilibrium flash vaporization calculation on the total feed to a separator where the net products are the same as in Case I but with 100 mols of the vapor being recycled. For this calculation $\frac{L}{V}=\frac{246}{154+100}=0.969.$

The flash vaporization calculations for this example are given in Table 6. A comparison of this solution and the one made for Case I proves that the recycle gas can be neglected in making equilibrium flash vaporization calculations for Case IV.

Thus it has been shown that all the cases of separation represented on Fig. 22 may be solved in essentially the same way and that the quantity of vapor or liquid recycle have no effect on the separation calculation.

USE OF RELATIVE VOLATILES

Phase equilibrium calculations involve successive approximations, which depend somewhat on experience and judgment. In order to reduce the amount of work and reduce the number of trials necessary, it has been proposed that relative volatilities be used in making bubble and dew point and flash vaporization calculations.

Kirkbride[5] presented relative volatilities referred to ethane as a reference component, including examples in the computation of bubble and dew points. Smith and Wilson[13] developed a technique for making flash vaporization calculations, using relative volatilities. These relative volatility procedures have time-saving possibilities if the process designer masters the technique but they have the disadvantage of being more difficult to comprehend and visualize. As illustrations of the relative volatility method, the bubble point and dew point examples solved by the conventional method in the last installment will be solved by Kirkbride's method. Also an equilibrium flash vaporization example will be solved.

Example 8. Bubble and dew points of an equimolal mixture of ethane, propane, n-butane, and n-pentane will be found by using volatilities relative to ethane and the following expressions.

TABLE 4. Flash vaporization calculations *(Example 5)*

	v	l	f	$K_{200\ psia}^{140\ F}$	$\frac{L}{VK}$	$\frac{f}{1+\frac{L}{VK}}$
C_2	69.75	36.9	106.65	3.70	0.527	69.75
C_3	46.25	65.4	111.65	1.38	1.412	46.25
C_4	26.30	90.0	116.30	0.57	3.42	26.30
C_5	11.70	107.7	119.40	0.212	9.2	11.70
	154.00	300.0	454.00			154.00 (check)

TABLE 5. Flash vaporization calculations *(Example 6)*

	Mols of feed			$K_{200\ psia}^{140\ F}$	$\frac{L}{V}=2.245$	
	Net products	Liquid recycle	Total feed		$\frac{L}{VK}$	$\frac{f}{1=\frac{L}{VK}}$
C_2	100	12.3	112.3	3.70	0.607	69.75
C_3	100	21.8	121.8	1.38	1.63	46.25
C_4	100	30.0	130.0	0.57	3.94	26.30
C_5	100	35.9	135.9	0.212	10.60	11.70
	400	100.0	500.0			154.00

$V=154.0;\quad L=500-154=346;\quad \frac{L}{V}=2.245$ (check)

TABLE 6. Flash vaporization calculations *(Example 7)*

	Mols of feed			$K_{200\ psia}^{140\ F}$	$\frac{L}{V}=0.969$		Net vapor product	Liquid product
	Net products	Vapor recycle	Total feed		$\frac{L}{VK}$	$\frac{f}{1+\frac{L}{VK}}$		
C_2	100	45.3	145.3	3.70	0.2615	115.05	69.75	30.25
C_3	100	30.0	130.0	1.38	0.702	76.25	46.25	53.75
C_4	100	17.1	117.1	0.57	1.700	43.40	26.30	73.70
C_5	100	7.6	107.6	0.212	4.57	19.30	11.70	88.30
	400	100.0	500.0			254.00	154.00	246.00

$V=154+100=254;\ L=246;\ \frac{L}{V}=\frac{246}{254}=0.969$ (check)

These bubble and dew point calculations are given in Tables 7 and 8, which are covered by the following discussion.

For bubble points:

$$\Sigma y = \Sigma(\alpha x)K_o \quad . \quad . \quad . \quad . \quad . \quad (24)$$

For dew points:

$$\Sigma x = \frac{\Sigma(\alpha y)}{K_o} \quad . \quad . \quad . \quad . \quad . \quad (25)$$

Where α = relative volatility = K/K_o

K_o = phase equilibrium constant for reference component.

In solving this problem Kirkbride's temperature correction chart will be used.

From the bubble point calculations given in Table 7 it can be seen that two trials were sufficient. This time saving is due to the chart Kirkbride includes for making "educated" assumptions. The use of relative volatilities alone does not greatly simplify the calculation.

When the first assumption is as close to the correct temperature, as it is in the dew point calculations given in Table 8, the advantage of Kirkbride's method is not as great. In this connection it is of interest to point out that the chart Kirkbride presents for adjusting temperature assumptions is limited to the cases where bubbles and dew point temperatures are involved. A similar plot for pressures would be useful.

Relative volatilities may also be used in computing flash vaporization. Smith and Wilson[13] presented a relative volatility method for making such calculations. The essence of this method is the use of v/l ratios for individual components and relative volatilities. By definition of K, the equilibrium constant, and the relative volatility:

$$\alpha_{B-C} = \frac{K_B}{K_C} = \frac{y_B/x_B}{y_C/x_C} \quad . \quad . \quad . \quad (26)$$

Multiplying numerator and denominator by V/L:

$$\alpha_{B-C} = \frac{\frac{K_B V}{L}}{\frac{K_C V}{L}} = \frac{v_B/l_B}{v_C/l_C} \quad . \quad . \quad . \quad (27)$$

From which:

$$\frac{v_B}{l_B} = \alpha_{B-C}\frac{v_C}{l_C} = K_B\frac{(v_C)}{(l_C K_C)}, \text{ etc.}$$

. . . . . (27A)

The calculation procedure proposed by Smith and Wilson is as follows:

Step 1. Select a reference component as the one at which K is close to unity.

Step 2. Assume a liquid-vapor distribution for the reference component only.

Step 3. Where T and P are not given assume temperature and pressure conditions and find K for each component.

Step 4. Compute v/lK for reference component.

Step 5. From this v/lK for reference component and the K values for each component, compute by means of equation (27A) the v/l ratios for each component.

Step 6. From these values of v/l, compute v and l for each component by using equations (23) and (23A).

Step 7. Find $V = \Sigma v$ and $L = \Sigma l$ and then calculate the equilibrium constant for the reference component as:

$$K_o = \frac{(L)}{(V)}\frac{v_o}{l_o}$$

where the subscript o applies to the reference component.

Step 8. Find temperature corresponding to this value of equilibrium constant, K_o, for the reference component.

Step 9. If the temperature found in Step 8 agrees with the assumed temperature, the solution is correct. If not, steps 3 to 8 must be repeated with another temperature.

Example 9. As an illustration of the Smith and Wilson[13] method, a flash calculation will be made on an equal molal mixture of C_2 C_3, nC_4 and nC_5 at 140 F and 200 psia. This is the same sample used previously to illustrate Case I separation.

Take propane as the reference component and assume a v/l of 46/54 = 0.85.

Next the calculations given in Table 9 are made and from these results:

$$\text{Calc } K_{C_3} = \frac{(46)}{(54)}\frac{(247)}{(153)} = 1.375$$

which is a good check with a K of 1.38 for 140 F.

This example illustrates the application of the Smith and Wilson method when the unknown is the per cent vaporized for a given temperature. Another type of problem that can be readily solved is finding the temperature for desired quantities of vapor and liquid.

Methods have been described for using relative volatilities in bubble and dew points and in flash vaporization calculations. Sets of relative volatility charts, such as those presented by Kirkbride[5], are useful in these computations. The drawbacks to such charts are: (a) The reference component might be different for different design problems, and (b) changes in the K constants for the reference component are reflected in the relative volatilities of the other components.

With reference to this last point, Kirkbride has proposed that an α plot could be made for the reference component to include these changes. Following this procedure could result in confusion if several corrections were superimposed on a given set of charts, particularly if several reference components were used in preparing the α charts and if there were glaring errors or inconsistencies in the basic K data used in preparing the first set of α charts.

HYPOTHETICAL COMPONENT BREAKDOWN

In some cases it is necessary to break down a petroleum fraction into a series of hypothetical components and estimate

TABLE 7. Bubble point computations using relative volatilities *(Example 8)*

Component	x	Assume 80 F		Assume 95 F	
		α 80 F 200 psia	αx	α 95 F 200 psia	αx
Ethane	0.25	1.00	0.2500	1.000	0.250
Propane	0.25	0.333	0.0833	0.3680	0.092
N-Butane	0.25	0.117	0.0293	0.1255	0.0314
N-Pentane	0.25	0.035	0.0087	0.040	0.0100
	1.00		0.3713		0.3834
		$K_o = \frac{1.00}{0.3713} = 2.7$ at 100 F		$K_o = \frac{1.00}{0.3834} = 2.63$ at 95 F	
		Assumed-obtained = 80—100 = —20, (assumed—correct) from chart = —15 F. correct F = 80+15 = 95 F.		which checks the assumed, giving bubble point 95 F.	

TABLE 8. Dew point computations using relative volatilities *(Example 8)*

Component	y	Assume 200 F		Assume 197 F	
		α 200 F 200 psia	y/α	α 197 F 200 psia	y/α
Ethane	0.25	1.000	0.250	1.00	0.25
Propane	0.25	0.382	0.655	0.387	0.66
N-Butane	0.25	0.182	1.375	0.184	1.36
N-Pentane	0.25	0.080	3.120	0.082	3.05
	1.00		5.400		5.32
		$K_o = \frac{5.40}{1.00} = 5.4$ at 198 F		$K_o = \frac{5.32}{1.00} = 5.32$ at 197 F	
		Correct temperature = 200—2 F = 198 This is so close chart can't be read.		which checks the assumed, giving bubble point of 197 F.	

TABLE 9. Flash vaporization computations using relative volatilities *(Example 9)*

Component	Mols feed f	$K^{140\text{ F}}_{200\text{ psia}}$	α	v/l	l	v
Ethane	100	3.70	2.68	2.28	30.6	69.4
Propane	100	1.38	1.00	0.85	54.0	46.0
N-Butane	100	0.57	0.413	0.351	74.0	26.0
N-Pentane	100	0.212	0.154	0.131	88.4	11.6
	400				247.0	153.0

for each of these components the fugacity equilibrium constants so that vaporization-condensation calculations may be made by the component method. This is particularly important where the system involved contains light hydrocarbons as well as the petroleum fraction and it is not practical to apply an empirical calculation method to the estimation of the phase equilibrium conditions.

The number of components into which the fraction must be broken is dependent upon the type of computation to be made and the accuracy desired. For example, in calculating dew points, the higher boiling portion of the fraction is the most important, whereas in calculating bubble points, the lower boiling portion is most important. In any event, such a hypothetical component breakdown will result in groups of actual components lumped together and identified as single hypothetical components. For each of these hypothetical components it is necessary to estimate or assign properties in order to permit computing the fugacities. The properties required are the density, the molecular weight, and the critical conditions. From these properties plus the boiling points and the percentages of each, it is possible to compute the mols of each component and to estimate the phase equilibrium distribution constants.

On Fig. 23, the true boiling point distillation curve of the typical petroleum fraction shown in Figs. 18, 19, and 20 is divided into hypothetical components by means of the chord area method. This involves drawing plateaus in such a way that the shaded areas above and below the curve balance. Each of these components is identified by its average boiling point on this TBP curve. The volume per cents of the components are then read from the lower scale.

In addition to the boiling points for each component, as obtained from Fig. 23, the densities must be obtained. This may be done directly if the density vs. volume per cent distilled curve is also available. Such a curve may be obtained at the same time the TBP distillation is run in the laboratory. If such a density or gravity curve is not available, then the gravities must be estimated. This may be done in the manner illustrated in Fig. 24.

On Fig. 24 the densities of hydrocarbons are plotted against the boiling points for paraffins, olefins, and aromatics. Estimating the hypothetical component densities involves successive approximations in order to obtain a total density equal to the known density of the mixture. The procedure for doing this is to draw a curve on the scales of Fig. 24 and then read points for each hypothetical component from this curve according to its boiling point. Using these densities, the density of the mixture is computed and compared with the known density of the mixture. If this calculated density differs from the known density, a new curve is drawn and the procedure repeated until a check is obtained.

Having the boiling points and densities of each hypothetical component, the

FIG. 23. Hypothetical component breakdown of typical petroleum fraction from the TBP distillation curve by the chord area method.

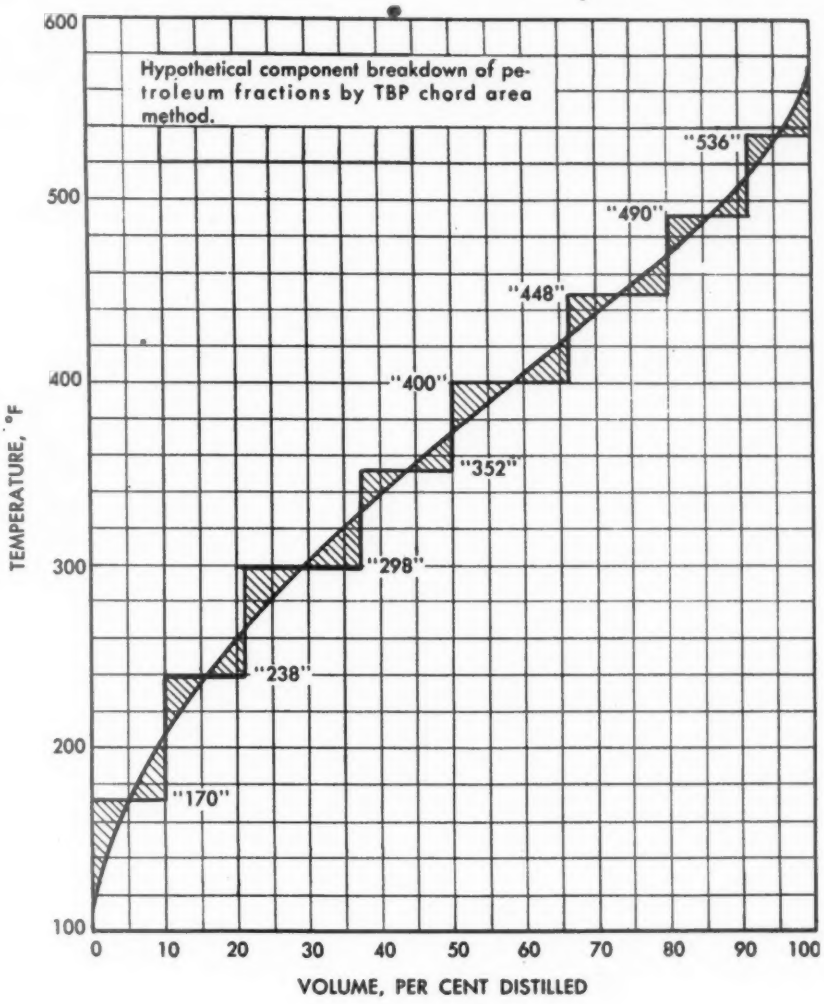
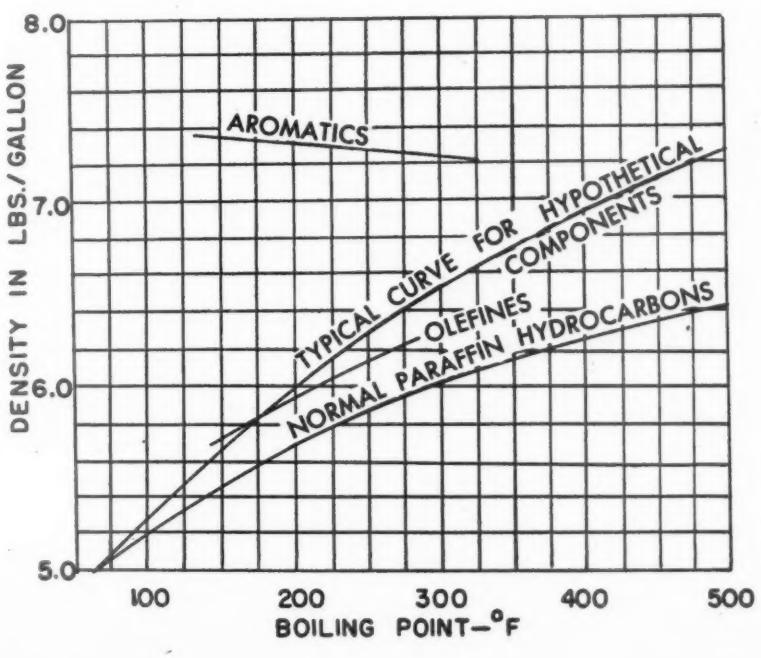


FIG. 24. Density vs boiling point plot for hydrocarbons, showing typical curve for hypothetical components.



next step is to estimate from correlations the critical temperatures and pressures and the molecular weights of each hypothetical component. With these the calculations of the fugacities proceed in a straightforward manner, using fugacity coefficients, such as the ideal fugacities obtained from P-V-T data or the empirical fugacities as developed by Kirkbride[6]. From this point on, the equilibrium vaporization-condensation calculations are as straightforward as those for known composition mixtures.

White and Brown[15] presented a theoretical component method for the prediction of high pressure vapor-liquid equilibria for complex hydrocarbon mixtures, in which the petroleum fraction is divided into hypothetical components from an analytical distillation and then phase equilibria predictions are made by using fugacity type equilibrium constants for each of the hypothetical components. The authors present a correlation for obtaining the equilibrium constants for the hypothetical components.

An example will illustrate the proposed method of making hypothetical component breakdowns and then finding the fugacity K constants for the components.

Example 10. Calculate the per cent of the petroleum fraction represented on Figs. 18, 19, 20, and 23 that will flash at 500 F and 100 psia.

For this petroleum fraction the volume percentages for each hypothetical component are given by the "chord-area" plateaus shown on Fig. 23. The "typical curve" on Fig. 24 gives the final trial made in computing the gravities of the components to add up to the known gravity of 43.2 deg API for the mixture.

In Table 10 are the calculations to determine the mol fractions for the hypothetical components.

The properties of each hypothetical component found by the above calculations are: (a) Boiling point, (b) gravity, and (c) molecular weight. From these properties and conventional data book correlations (not shown because of space limitations) the critical properties are found and are given in the followering table. Vapor pressures at 500 F are found and likewise listed. Reduced temperatures and pressure are next found and the f/P coefficient for the vapor and total pressure conditions are found.

The critical conditions were obtained from correlations involving the boiling point and gravity of each component. Having the atmospheric boiling point and the critical point for each component, the vapor pressures at 500 F were found from a vapor pressure plot by drawing a line through these two points and reading the pressures at the intersection with 500 F. See Tables 11 and 12.

The 22.5 per cent result of the hypothetical component flash vaporization calculation is probably more accurate because the flash curves shown on Fig. 18 were obtained by means of an assumed focal point and the phase diagram construction shown on Fig. 19. This latter method would check more closely if the focal point had been more precisely determined. There is no direct and accurate method of estimating this focal point for petroleum fractions, however.

It is obviously too much trouble to go through the above fugacity calculation each time K constants are required for hypothetical components. The work of White and Brown[15] is of interest in this connection.

In estimating the K constants for hypothetical components for a given temperature and pressure, it is helpful to plot K constant vs boiling point on semi-log paper with K on log scale. Such a plot will smooth out the computed constants and make it possible to get by with a minimum amount of tedious f/P computations.

TABLE 10. Hypothetical component breakdown calculations *(Example 10)*

Component	Liquid, volume per cent	BP, F	Gravities			Mol weight	Mols per 100 gal mixture	Mol fraction
			Lb per gal components	Lb per 100 gal mixture	Deg API			
"170"	10	170	5.80	58.0	71.6	90	0.644	0.1377
"238"	11	238	6.25	68.8	57.0	109	0.631	0.1350
"298"	16	298	6.50	104.0	49.7	126	0.826	0.1765
"352"	13	352	6.75	87.5	43.1	142	0.616	0.1316
"400"	16	400	6.90	110.4	39.3	160	0.691	0.1476
"448"	14	448	7.10	99.4	34.5	180	0.552	0.1180
"490"	11	490	7.25	79.7	31.0	195	0.409	0.0874
"536"	9	536	7.40	66.6	27.7	215	0.310	0.0662
	100			674.4			4.679	1.000

$$\text{Mixture molecular weight} = \frac{674.4}{4.679} = 144$$

TABLE 11. Fugacity K constants for hypothetical components *(Example 10)*

Component	Critical conditions		Vapor pressure at 500 F in psia	π/P	T_R at 500 F	Reduced pressure, P_R		f/P Coefficients		$\frac{f_\pi}{\pi} \Big/ \frac{f_P}{P}$	$K^{500\ F}_{100\ psia}$ *
	Temp., F	Pressure, psia				at vapor pressure	at total pressure	$\frac{f_\pi}{\pi}$	f_P / P		
"170"	480	455	500	5.0	1.02	1.100	0.220	0.640	0.930	0.688	3.34
"238"	564	417	260	2.6	0.936	0.623	0.240	0.720	0.885	0.814	2.12
"298"	635	393	145	1.45	0.876	0.369	0.254	0.790	0.855	0.924	1.34
"352"	700	366	78	0.78	0.826	0.213	0.273	0.855	0.815	1.050	0.82
"400"	755	345	46	0.46	0.790	0.133	0.290	0.890	0.775	1.150	0.53
"448"	810	326	26	0.26	0.755	0.080	0.306	0.925	0.745	1.240	0.32
"490"	855	310	17	0.17	0.730	0.055	0.322	0.940	0.710	1.325	0.226
"536"	900	295	10	0.10	0.705	0.034	0.340	0.950	0.680	1.400	0.140

$$*K = \frac{\pi}{P} \frac{f_\pi/\pi}{f_P/P} = \frac{f_\pi}{f_P}$$

Next make equilibrium flash vaporization calculation for 100 gallons of above mixture, using above K constant and equation (23). See table 12 below for these calculations.

TABLE 12. Flash vaporization calculations for petroleum fraction *(Example 10)*

	f	$K^{500\ F}_{100\ psia}$	Assume L/V=3.0		Vapor		Liquid	
			$\frac{L}{VK}$	$\frac{f}{1+\frac{L}{VK}}$	Mols	Gallons	Mols	Gallons
"170"	0.644	3.34	0.898	0.340	0.340	5.28	0.304	4.72
"238"	0.631	2.12	1.45	0.258	0.258	4.50	0.373	6.50
"298"	0.826	1.34	2.24	0.255	0.255	4.94	0.571	11.06
"352"	0.616	0.82	3.66	0.132	0.132	2.80	0.484	10.20
"400"	0.691	0.53	5.66	0.104	0.104	2.40	0.587	13.60
"448"	0.552	0.32	9.37	0.053	0.053	1.34	0.499	12.66
"490"	0.409	0.226	13.3	0.0288	0.0288	0.80	0.3802	10.20
"536"	0.310	0.140	21.4	0.0139	0.0139	0.40	0.2961	8.60
	4.679			1.1847	1.1847	22.46	3.494	77.54

$V = 1.1847$

$L = 4.679 - 1.1847 = 3.4943$

$$\frac{L}{V} = \frac{3.4943}{1.185} = 2.96 \text{ (check)}$$

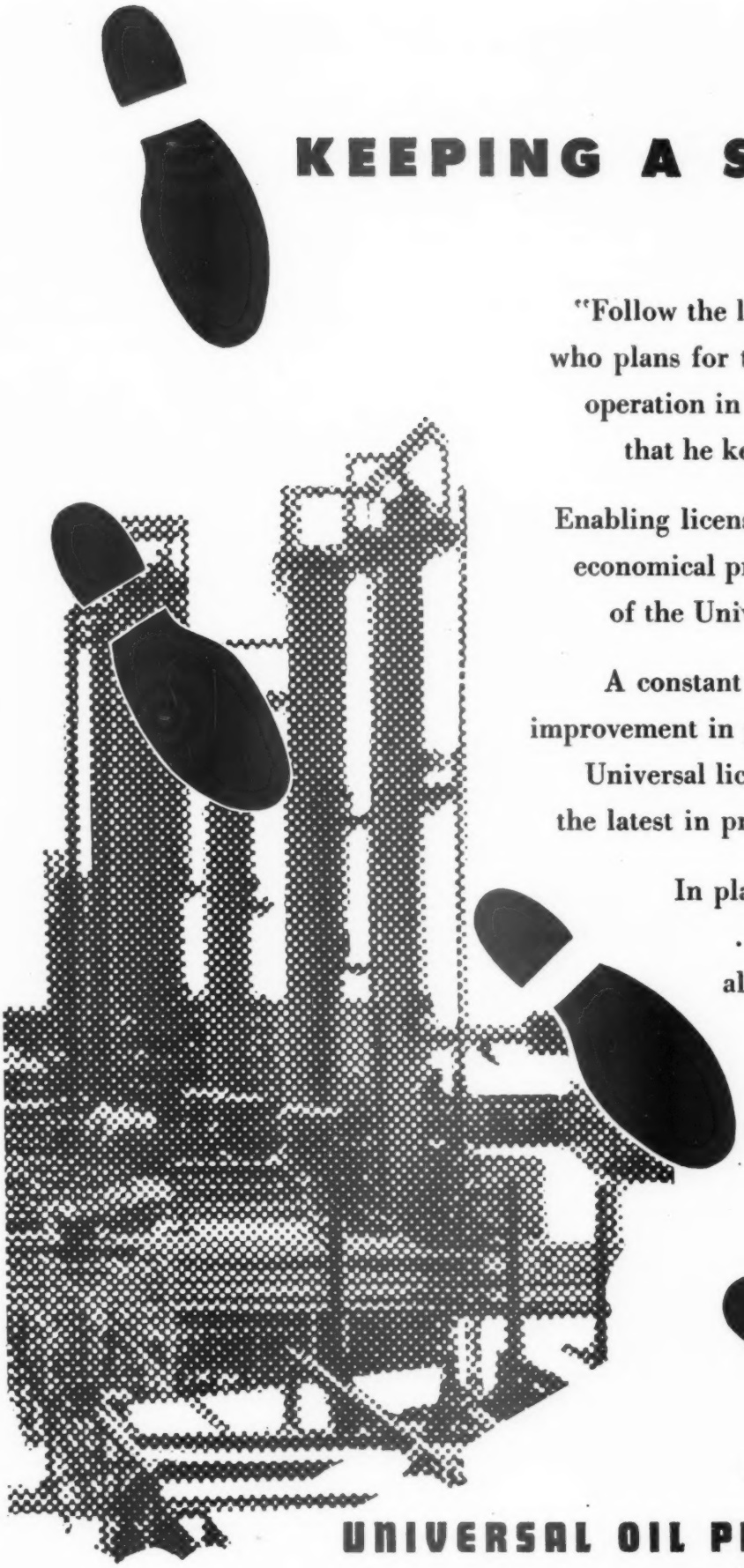
Liquid volume per cent flash vaporized at 100 psia and 500 F = 22.5 per cent.
The result of this calculation 22.5 per cent compares with 20 per cent shown on the flash curves given in Fig. 18.

EQUILIBRIUM FLASH VAPORIZATION PREDICTIONS

As pointed out in Part 3 of this series, vaporization and condensation of petroleum fractions may be calculated by means of empirical correlations based on analytical distillations of the fractions or by breaking the mixture down into hypothetical components and using fugacity equilibrium phase distribution constants. For most work the empirical flash vaporization curve technique is satisfactory and preferable.

Several empirical correlations have been proposed for making equilibrium flash vaporization calculations for petroleum fractions. None of the methods available is completely satisfactory or widely accepted. The method desired should include a procedure for estimating the properties of the equilibrium vapor and liquid as well as correcting the flash vaporization curve for pressure.

KEEPING A STEP AHEAD



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One of the earliest methods suggested was presented in 1929 by Piromoov and Beiswenger[11], which article contains experimental flash vaporization data as well as correlations for estimating the flash vaporization curves. In this work it was proposed that the flash curves at higher pressures be drawn by finding the midpoint from a vapor pressure chart and displacing it parallel to itself, which says that the flash curve slope is constant at every pressure. Packie[10] makes this same simplifying but erroneous assumption.

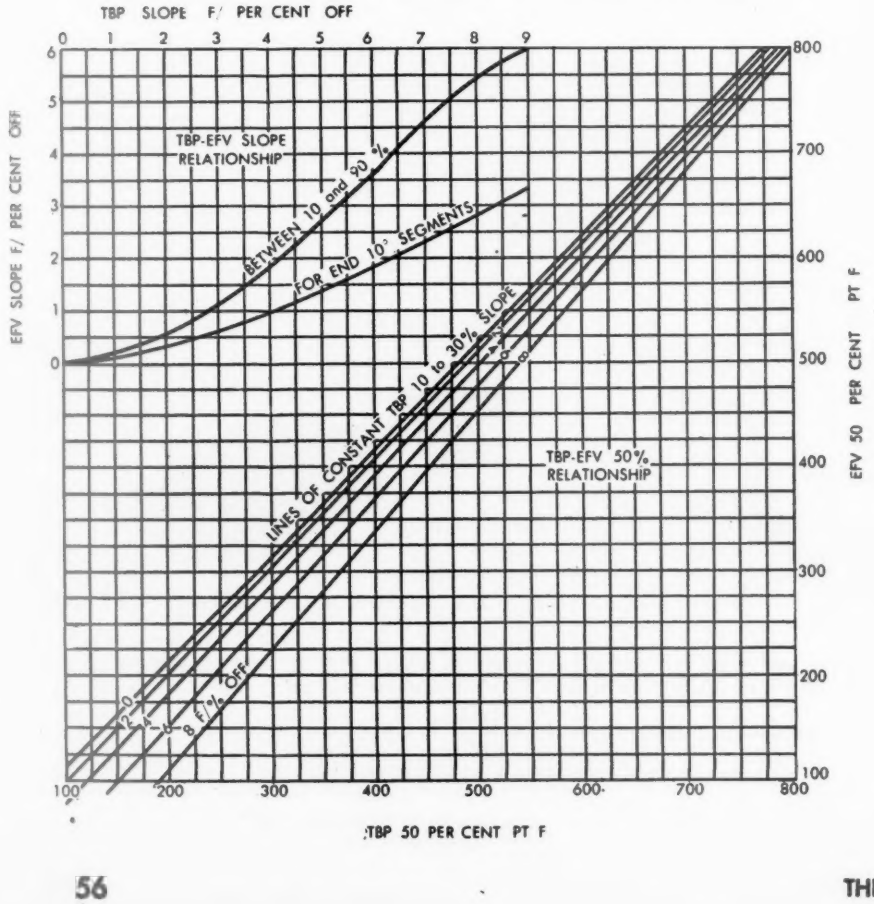
Although several technical contributions have been made on this subject during the last eight years since it was proposed, there is still no reliable method available for estimating accurately equilibrium conditions at various pressures and predicting properties of equilibrium vapor and liquid. Katz and Brown[4] suggested a method of correcting the flash curve to higher than atmospheric pressure and Obryadchikov[9] presented a correlation of the distillation properties of the equilibrium vapor and liquid. Although these contributions do not solve the problem they do suggest possibilities for further work.

Most of the experimental equilibrium flash vaporization data available were taken at atmospheric pressure although some data have been obtained at superatmospheric presure. References to a few of the publications on this subject are given at the end of this chapter [1, 2, 4, 7, 8, 9, 10, 11, 12, 14]. Some of these references contain observed data and most of them include empirical flash curve calculation methods.

In general the procedure is to prepare a phase diagram like Fig. 19, or flash curves, like those shown on Fig. 18. This is done by the following steps: (a) Predict the atmospheric EFV curve, (b) estimate the critical and/or focal point, and (c) construct the phase diagram on a Cox type vapor pressure chart. The method of constructing the phase diagram has received considerable attention without much actual data at high pressures being available.

Fig. 25 is an empirical correlation of the equilibrium flash vaporization and true boiling point curves. This correlation was developed by applying theoretical considerations to observed data obtained from the literature. It will be noted that this plot is similar to Nelson's [7, 8] correlation. The lower part gives the 50 per cent point relationship, whereas the upper part is the slope relationship. The EFV 50 per cent point is a function of the TBP 50 per cent and 10-30 per cent slope, as shown. Except for the first and last 10 per cent increments, the slopes of the TBP and EFV curves fall on one curve, as shown in the upper lefthand corner of Fig. 25. This does not mean that the EFV curve is straight between the 10 and 90 per cent points. On the contrary, the EFV curve will reflect irregularities in the TBP curve. The slope relationship is applied to 10 per cent increments.

FIG. 25. Equilibrium flash vaporization vs. true boiling point relationship for petroleum fractions at atmospheric pressure.


TBP SLOPE F/ PER CENT OFF
EFV SLOPE F/ PER CENT OFF
TBP-EFV SLOPE RELATIONSHIP
BETWEEN 10 and 90 %
FOR END 10% SEGMENTS
LINES OF CONSTANT TBP 10 to 30% SLOPE
TBP-EFV 50% RELATIONSHIP
EFV 50 PER CENT PT F
TBP 50 PER CENT PT F

The existence and importance of the "focal" or "critical intersection" point was brought out in 1933 by Ragatz, McCartney, and Haylett[12], by Katz and Brown[4], and by Watson and Nelson[14]. Ragatz et al observed that the initial and final temperatures of a hydrocarbon mixture converge and finally intersect as pressure is increased. Watson and Nelson[14] showed that a line drawn through the molal average boiling point on a Cox vapor pressure chart with the same slope as the nearest hydrocarbon will pass through a critical intersection or focal point. Watson and Nelson also noted that the distance from the focal point to the critical point was one-fifth the distance from the critical to the temperature at atmospheric pressure, the distance being measured along the molal average boiling line. Nelson and Souders[7] proposed correcting the 50 per cent point on the EFV by following a pure hydrocarbon vapor pressure line and then locating the focal point by the same one-fifth proportion used by Watson and Nelson[14].

These methods of drawing the phase diagram are clumsy. A more direct procedure would be to predict the focal point directly from the properties of the mixture, if only such a correlation were available, which it isn't. Another method is that proposed by Katz and Brown[4], who suggested using equivalent slopes.

In this procedure Katz and Brown suggested a plot similar, but not identical, to Fig. 26 for correcting of the TBP, ASTM, and EFV slope for pressure. In the original plot reduced pressures computed from the critical pressure were used. The focal rather than the critical point should be the reference used in computing reduced pressure. In addition, this writer does not recommend using the ASTM distillation in this type of correlation. Making these two changes in the basic idea, Fig. 26 was constructed. From Fig. 26 the slope of a TBP or EFV curve may be found at other pressures from the slope at atmospheric pressure and the focal pressure. This corrected slope may be used along with the vapor pressure chart to correct an EFV curve to higher pressures.

Fig. 26 also has other applications. It may be used to correct the slope of the TBP distillation curve to higher pressures. This high pressure TBP may be used directly in making EFV predictions. Another application of Fig. 26 will be shown in a later article of this series.

In most empirical correlations of EFV data, the TBP and ASTM distillation curves are used. This often leads to errors because the correlations based on the ASTM distillations are not as reliable as the TBP ones. It is recommended that the TBP curve be used in this type of work. Where ASTMs are desired on the products, etc., they may be estimated by Geddes'[3] method. Likewise the TBP of the feed stock may be estimated where it is not known in order to use TBP-EFV correlations.

Empirical flash curve correlations available in the literature use the slope and the 50 per cent point or the point at which the EFV intersects the ASTM or

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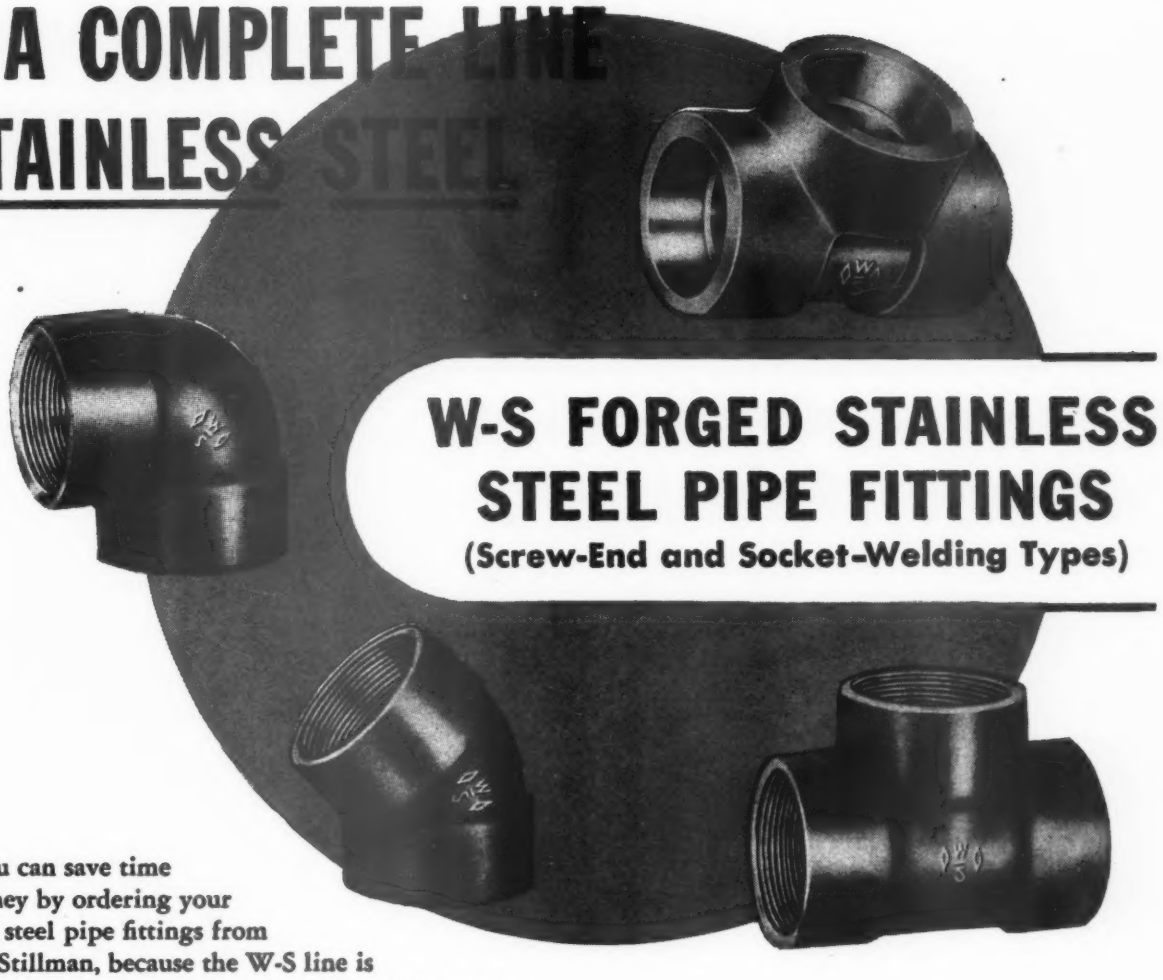

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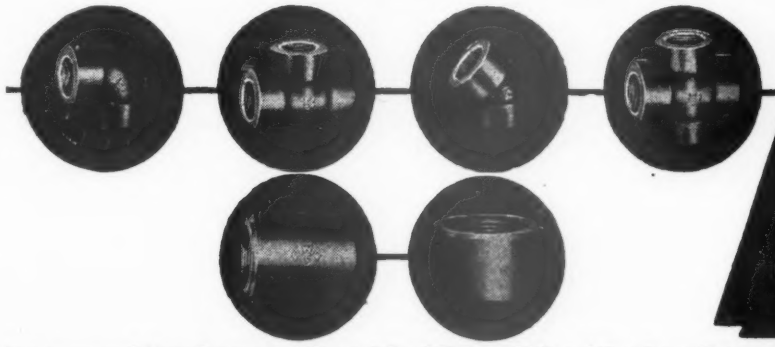

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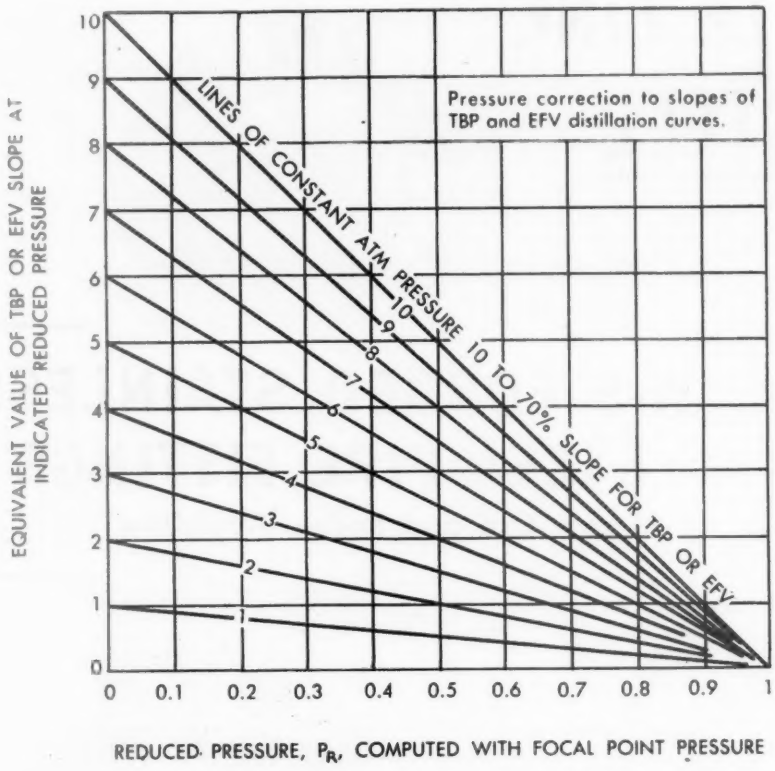
Pressure correction to slopes of TBP and EFV distillation curves.
LINES OF CONSTANT ATM PRESSURE
10 TO 70% SLOPE FOR TBP OR EFV
EQUIVALENT VALUE OF TBP OR EFV SLOPE AT INDICATED REDUCED PRESSURE
REDUCED PRESSURE, P_R, COMPUTED WITH FOCAL POINT PRESSURE

FIG. 26. Equivalent or corrected slopes of TBP and EFV distillation curves for super-atmospheric pressures.

TBP curve and then construct the EFV curve as a straight line with some curvature applied to the ends. Experimental flash vaporization data indicate that the EFV curves are not straight but sinuous and that the curvature follows that of the analytical distillation curves, TBP or ASTM.

This suggests building up the EFV in segments, starting at a given point such as the 30 or 50 per cent point and going up by 10 per cent increments. With such a method the TBP and EFV slopes at different parts of the curve would be correlated. It should be possible to use Fig. 26 to correct these slopes to higher pressure and thereby construct an EFV curve at super-atmospheric pressures directly.

In developing and using empirical phase equilibrium methods, such as the flash vaporization correlations described above, the question arises as to whether or not equilibrium is actually reached. Continuous flash vaporization experiments have been run at different rates by this author[1] and no effect of time was found for the range covered. Of course, the important consideration is the application of the resulting correlations in design and it might be stated that the uncertainty as to the closeness of approach to equilibrium cancels out since the correlation is merely a mechanism of going from one set of operating conditions to another. This is true within limitations. If the empirical flash vaporization correlations were based on experimental data where equilibrium was not actually reached, then this method could not be used. Such an empirical method could not be used with plate efficiencies developed by applying component phase equilibrium calculations to plant performance data.

The applications of Figs. 25 and 26 are illustrated by an example:

Example 11. For the petroleum fraction, whose TBP distillation curve is given in Fig. 23, estimate the atmospheric flash vaporization curve as shown on Fig. 18. Then using an assumed focal point the flash curves at higher pressures are estimated. The following Table 13 gives the calculations using Fig. 25 for building the EFV curve up in 10 per cent increments from the TBP curve, starting at the 10 per cent point and working both ways. The 10 to 30 per cent TBP slope is 4.9.

Assuming a focal point of 700 psia and 820 F (the focal point is probably a function of the gravity and distillation properties of the mixture but no correlations are available) permits applying Fig. 26 to this fraction at 100 psia.

$$P_R = \frac{100}{700} = 0.143$$

TBP 10 to 70 per cent slope
at atm. pressure = 3.9 °F/%
at 100 psia = 3.3 °F/% (from Fig. 26)
EFV 10 to 70 per cent slope
at am. pressure = 1.74 °F/%
at 100 psia = 1.4° F/% (from Fig. 26)

Referring to Fig. 18, the EFV 10 to 70 per cent slope at 100 psia is found to be 1.3° F/% as compared with a slope of 1.4° F/%for the 100 psia EFV curve on estimated Fig. 26.

Using the TBP 10 to 70 per cent slope at 100 psia of 3.3° F/% and Fig 25, the corresponding EFV 10 to 70 per cent slope at 100 psia is found to be 1.3° F/%. This latter slope is in better agreement with the result obtained by constructing the phase diagram, Fig. 19, which is the way the flash curves on Fig. 18 were obtained.

From the above discussion it can be seen that considerably more development work is necessary to prepare satisfactory tools for making empirical equilibrium flash vaporization calculations. It should also be evident from the above outline the form these correlations might take.

TABLE 13. EFV curve from TBP curve *(Example 11)*

Liquid volume, per cent off	True boiling point		Atmospheric flash curve	
	Temp., F	Slope, °F/per cent	Slope, °F/per cent	Temp., F
0	115			248
		9.0	3.4	
10	205			281
		5.5	3.1	
20	260			312
		4.3	2.0	
30	303			332
		3.7	1.6	
40	340			348
		3.2	1.2	
50	372			360
		3.3	1.3	
60	405			373
		3.2	1.2	
70	437			385
		3.3	1.3	
80	470			398
		3.9	1.8	
90	509			416
		6.1	1.9	
100	570			435

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★ ★ ★

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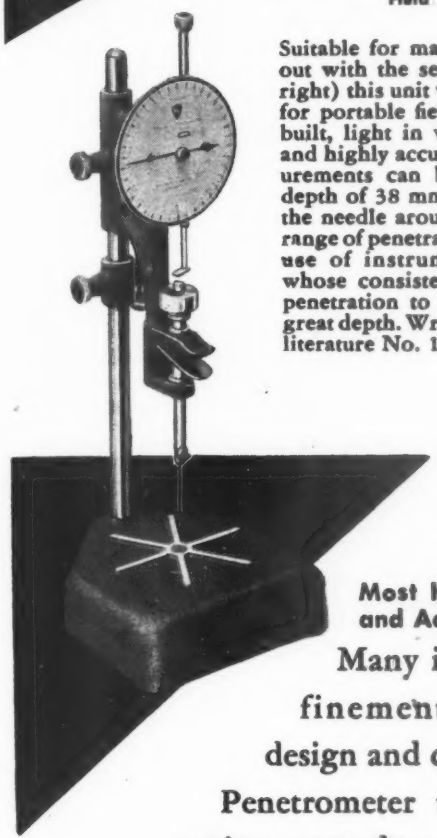
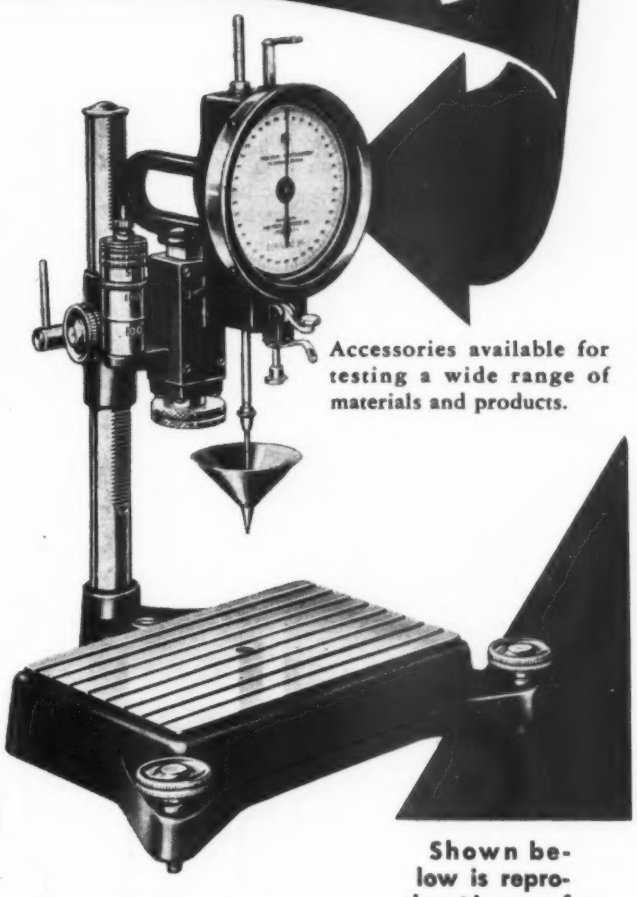


Suitable for many of the tests carried out with the senior model (shown at right) this unit was designed primarily for portable field use. It is compactly built, light in weight, easy to handle and highly accurate. Penetration measurements can be made directly to a depth of 38 mm. on a single sweep of the needle around the dial. This wide range of penetration readings facilitates use of instrument on substances whose consistency permits rapid penetration to a comparatively great depth. Write for detailed literature No. 10284-D-1.



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Free pump latest thing in hydraulics

By RICHARD SNEDDON, *Pacific Coast Editor*

SIMPLICITY is the keynote of a new, distinctly outstanding development—the free pump.* This is a unique piece of equipment, differing from the standard hydraulic production unit by being in several important respects as free as the name implies. At the will of the operator and without the use of a line or a winch, the complete pump in compact assembly is lowered to its seat at the working level or raised to the surface by the mere switching of a valve.

EXCLUSIVE

It reduces the process of well pulling to a virtually automatic status, and entirely eliminates the need for derricks and servicing equipment. In so doing, it is asserted, the free pump adds to ultimate production, for by substantially lowering pumping costs, it correspondingly extends the economically productive life of wells now active and permits the return to activity of shut-in wells considered to have been depleted beyond the point of profitable production.

Responsible for this latest and most ingenious adaptation is Clarence J. Coberly, Sr., who introduced hydraulic pumping to the petroleum industry just 15 years ago, and whose organization has been engaged in an intensive research effort for the last 8 years to perfect the last detail of free pumping. The new unit has not become a volume product without the most careful testing; experimental installations have been in service for a number of years in many fields under a wide variety of conditions. Now that it has actually gone into production permanent installations are being made rapidly in all parts of the country. The following information is derived from observation of the several units that are in service on a large oil lease in the Los Angeles area.

On this lease are 26 wells, 23 of which are produced with conventional Kobe pumps, and 3 with free pumps, the latter being the first changeovers in a general program of conversion. Incidentally, it is to be noted that the prior equipment is not rendered obsolete by the newest development, but can be easily converted to the free style pumping by a few simple adjustments. The central power plant for the lease consists of a battery of triplexes with appropriate power oil storage and a manifold that permits pressure control on each individual well, together with a metering arrangement that gives the measure of power oil used and production oil recovered for each. This system is serviced and supervised by one pumper only.

There were, as already intimated, three free pumps in operation on this lease, two operating on parallel strings and one concentrically, and full opportunity was provided to examine these intimately. Basically, it should be pointed out, the new unit is an adaptation of the conventional Kobe hydraulic pump, which features a nose assembly, carrying rubber packers as a means of raising and lowering the pump in the well, and a shoe that has been altered to facilitate

*Manufactured by Kobe, Inc., a Dresser Industries Company.

FIG. 1

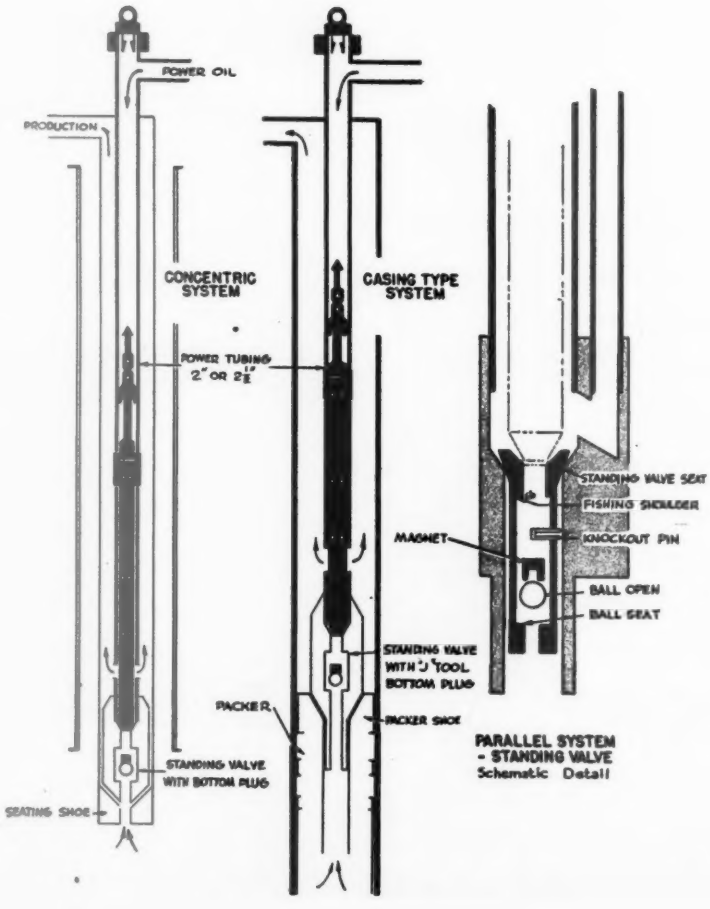
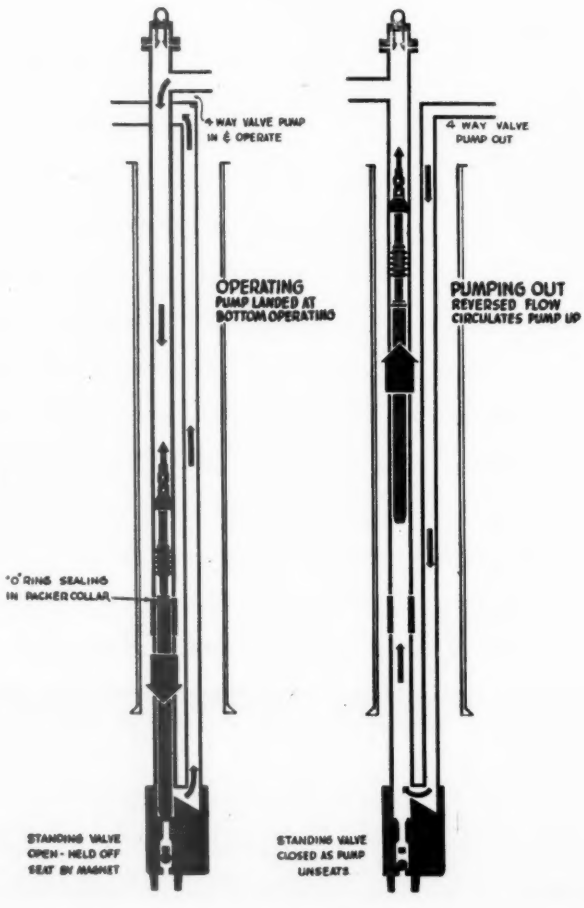
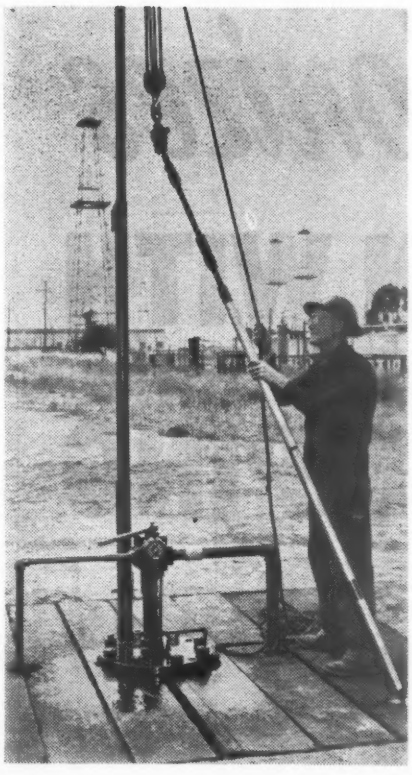


FIG. 2


4 WAY VALVE PUMP IN & OPERATE
4 WAY VALVE PUMP OUT
OPERATING
PUMP LANDED AT BOTTOM OPERATING
PUMPING OUT
REVERSED FLOW CIRCULATES PUMP UP
'O' RING SEALING IN PACKER COLLAR
STANDING VALVE OPEN - HELD OFF SEAT BY MAGNET
STANDING VALVE CLOSED AS PUMP UNSEATS



View of 2-in. free pump following its removal from well. The packer nose assembly, equipped with cup type rubber packers, is shown just above pumper's left hand. The packers provide the lifting area to circulate the pump to the surface and aid in reseating. The packer nose assembly marks the principal difference between the appearance of the conventional Kobe hydraulic pump and the free pump.

the seating of the pump above the standing valve. Otherwise, the pump still consists of a hydraulically actuated engine end and a pump end housed together in a long stainless steel barrel. The entire operation is controlled by a 4-way valve at the wellhead.

To circulate the pump to the surface, the handle of the valve is turned to the "pump out" position, which alters the direction of power oil flow. To reseat the pump, flow is again directed down the power oil line by switching the valve to the "pump in" position. Incidentally, the accompanying photographs were taken while the pumper circulated to the surface a pump set in a parallel string at 5000 ft. It was exactly 55 minutes from the instant the valve was set until the trigger clicked announcing the arrival of the pump at the surface, and it took a neat 40 minutes to send it back to the operating position.

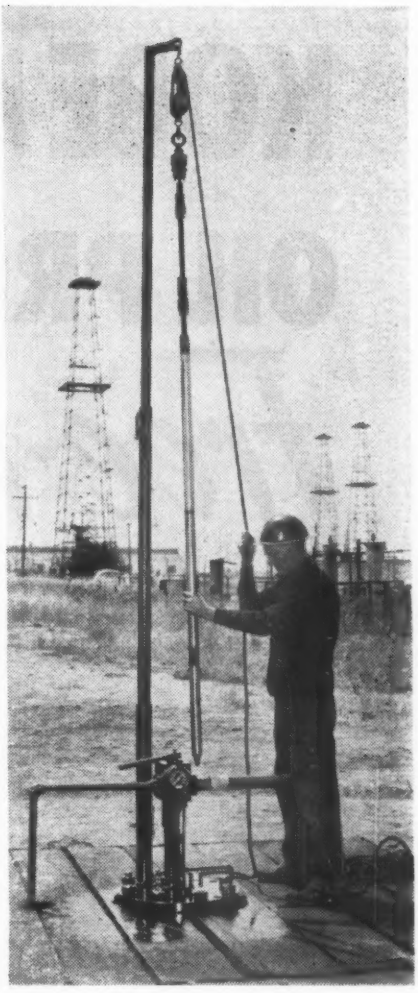
The principle of free movement is perhaps best understood by examining the parallel string installation, which functions as follows: Two parallel strings of tubing are run into the hole. They consist of 2-in. or 2½-in. power oil tubing, depending on the size of the pump to be used, and a parallel string of 1-in. or 1¼-in. production tubing. These are run into the hole simultaneously, and are tied together with specially designed clamps. The strings are joined at the bottom in a standing valve, which is lowered in the well to the desired pumping depth. Thus, with the standing valve closed, both tubes remain full of fluid, and blocked off from the producing section. They constitute in actuality a "U" tube, inside of which and at the bottom stands the pump. By utilizing the limbs of the tube alternately as power lines, the pump can be brought to the surface or seated as desired. When the standing valve is open to the producing formation, it is held off seat magnetically.

When running in a free pump, it is lowered into the power tubing at the wellhead, pushed down a few inches below the top of the 4-way valve, and the catcher (for trapping the pump when it returns to the surface) is locked in place. The valve handle is then turned to the "pump in" position, directing the power oil down the tubing, and carrying the pump toward its seat. When it reaches the seat, the O ring forms a seal in the packer collar so that the power oil is forced into the engine end of the assembly to operate the pump. The pumped fluid and the exhausted power oil return to the surface through the small production tubing. The pumper can tell that the pump is seated and in action, by the pressure reading on the 4-way valve gauge, and the pulsating of the needle with each pumping stroke.

To resurface the pump, the 4-way valve is turned to the "pump out" position, directing the power oil down the small tubing, and connecting the large tubing with the lead-line. The power oil exerts pressure underneath the pump, on the full area minus the area of the pump bottom plug, which is open to formation pressure through the standing valve. On top of the pump the fluid column exerts pressure on the full area of the pump. It is only this pressure differential that must be overcome to unseat the pump. As the pump is unseated a quick rush of fluid through the standing valve overcomes the force of the magnet, and the ball check is closed.

It may take as high as 850 psi to unseat the valve, but once off seat, the full area of the pump packer (same as the tubing) becomes effective lifting surface, and very little pressure is required. For instance, with a 2-in. pump, weighing 60 lb, and an effective lift area of approximately 3 sq in., the pressure required to lift the pump is $60 \div 3 = 20$ psi. The surfacing packers obviously do not have much work to do and their principal job is to maintain an effective seal against varying tubing diameters, joint enlargements and recesses, or other irregularities. In this connection, during the experimentation period, a 2-in. pump was circulated to the surface from a depth of 7500 ft without the aid of packers and employing nothing more than a high circulation rate.

When the pump reaches the top of the hole the nose slides into the catcher automatically releasing a trigger that is

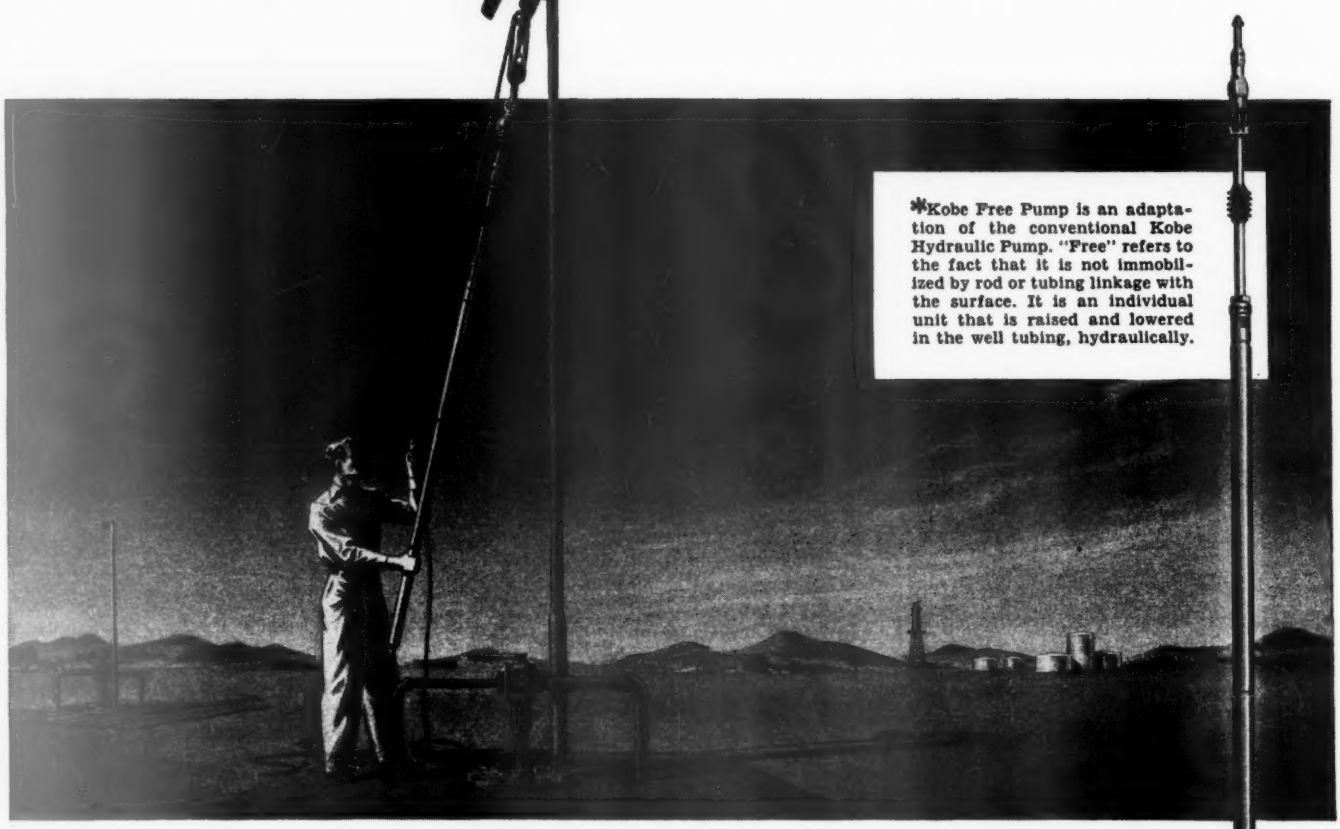


Preparing to run new free pump into well. The 4-way valve handle remains in the "shutoff and bleed" position until the pump is released for seating.

visible evidence of the fact that it has surfaced. To bleed off the pressure from the two strings of tubing the 4-way valve handle is set at the "shut-off and bleed" position, after which the pump catcher, which can not be moved until the pressure has been released, is unlocked by a one-eighth turn permitting the pump to be lifted out of the hole. Rubber wipers set in the 4-way valve remove excess oil from the outside of the pump as it is lifted out of the tubing. The mast shown in the photographs is used by the pumper for the more convenient handling of the pump and is a product of his own ingenuity. It is completely portable and he carries it in his service truck at all times.

In the concentric installation, of which some mention has already been made, the system of operation is very similar to that of the parallel strings with the tubing annulus representing the production leg of the "U" tube. This system is particularly suitable for deep settings and for follow-up in the decline of large wells, where the installed production tub-

KOBE *Revolutionizes* OIL PRODUCTION WITH *Free-Type** PUMPING



*Kobe Free Pump is an adaptation of the conventional Kobe Hydraulic Pump. "Free" refers to the fact that it is not immobilized by rod or tubing linkage with the surface. It is an individual unit that is raised and lowered in the well tubing, hydraulically.

Your conception of oil well pumping will be entirely changed when you see the Kobe Free Pump in operation. It opens a new era in oil production. For the first time, you are put in position to keep your subsurface equipment geared to changing downhole conditions. This is possible because the Free Pump can be run in and out of the hole by simply turning a valve.

The Free Pump ends pump pulling, costly downtime, and lost production. It eliminates the need for derricks and expensive servicing equipment. Lengthens the life of subsurface tubing by eliminating excessive wear and by keeping tubing clean. And, it utilizes the full efficiency of *Fluid Power* Pumping.

The passing of pump pulling ends an operation that the industry says annually takes 25% of the pumping operating dollar.

The Free Pump allows undreamed of versatility in your operations. Permits you to quickly and inexpensively change pumps, or to switch pumps from well to well. Big volume pumps no longer need be left in small volume wells. Cost is eliminated as a factor in determining your pump changes. Production planning is freed of the fetters of immobile pumping equipment.

Producers, now using *Fluid Power* Pumping, will find their equipment adaptable to Free Type Pumping. And at low cost!

KOBE **FREE TYPE PUMPING IS THE GREATEST**

The pump that's surfaced and seated *by the turn of a valve*

The new Kobe Free Pump reduces pump "pulling" to a one-man operation, as simple as gauging a lease tank.

When it becomes necessary to change a Free Pump, the pumper drives out to the well with the new pump. On arriving, he turns the handle of the 4-way valve on the wellhead to the "pump out" position. This reverses the oil flow and starts the pump up the tubing.

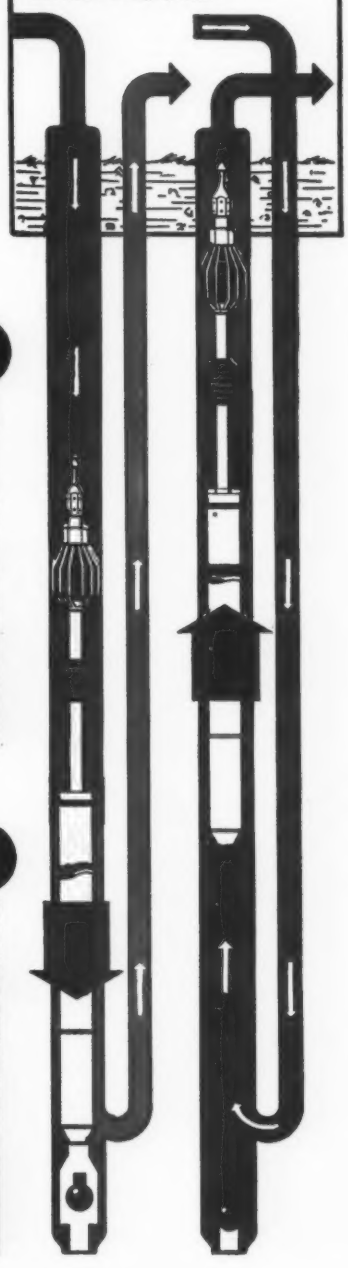
On surfacing, a target in the pump catcher signals its arrival. The pumper then turns the valve handle to the "shutoff and bleed" position to bleed off the pressure, and proceeds to lift the old pump from the well. The new pump is then inserted in the tubing, and the valve handle turned to the "pump in" position. This directs the power oil down the power tubing and starts the pump on its way. As soon as it reaches bottom, it will start pumping oil.

The round trip takes from one to three hours, depending upon the depth of the well. The cost and downtime is negligible. The Free Pump reduces an expensive, time-consuming field operation to the simple turning of a valve.

HOW PARALLEL SYSTEM WORKS

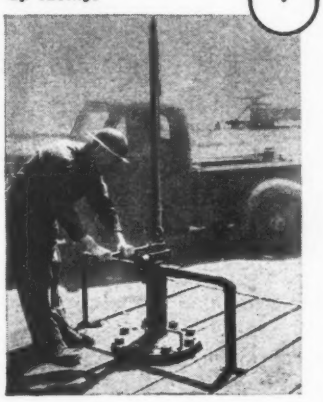
TO SEAT: Oil pressure is directed down power tubing, forcing pump to seat. On seating pump forces production oil up small production tubing.

TO SURFACE: Flow of power oil is reversed down production tubing, forcing pump off seat and up power tubing. At top, pump slides into catcher and is lifted from well.



TO SURFACE PUMP

1 *Turning 4-way valve handle to "pump out" position to unseat pump and start it up tubing.*



2 *Running up collapsible mast to which block and tackle has been attached to lift pump from well.*

3 *Removing surfaced pump from well. Total elapsed time for 5,000-foot well, 55 minutes.*

TO SEAT PUMP

4 *Hooking new pump into catcher preparatory to lowering it into well from pick up truck.*

5 *Inserting pump into tubing. Valve handle, controlling oil flow, is in "bleed" position.*

6 *Turning valve to "pump in" position to start pump down well. Running in time, 40 minutes.*

WRITE FOR BOOKLET. To learn how the Kobe Free Pump can reduce your pumping costs and simplify your production problems, write for the booklet, "Free Type Pumping." It will be forwarded without obligation. Please print your name and address.

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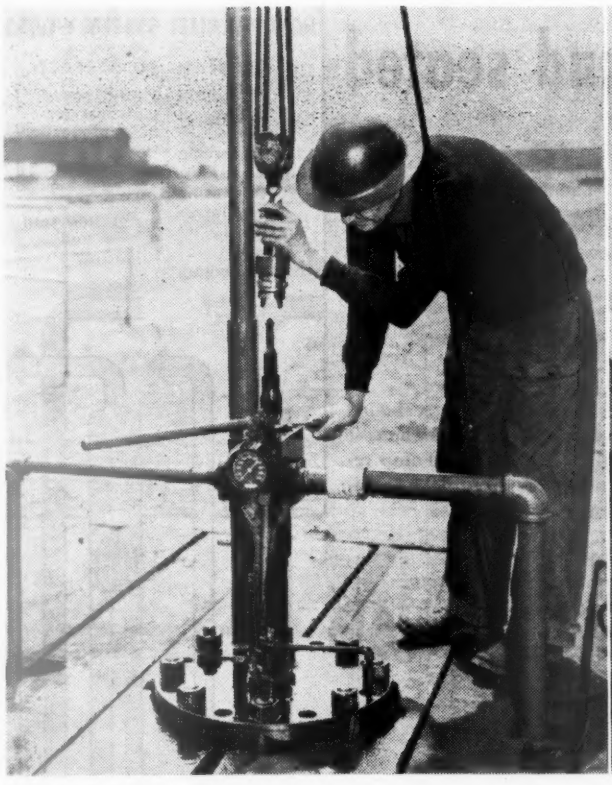
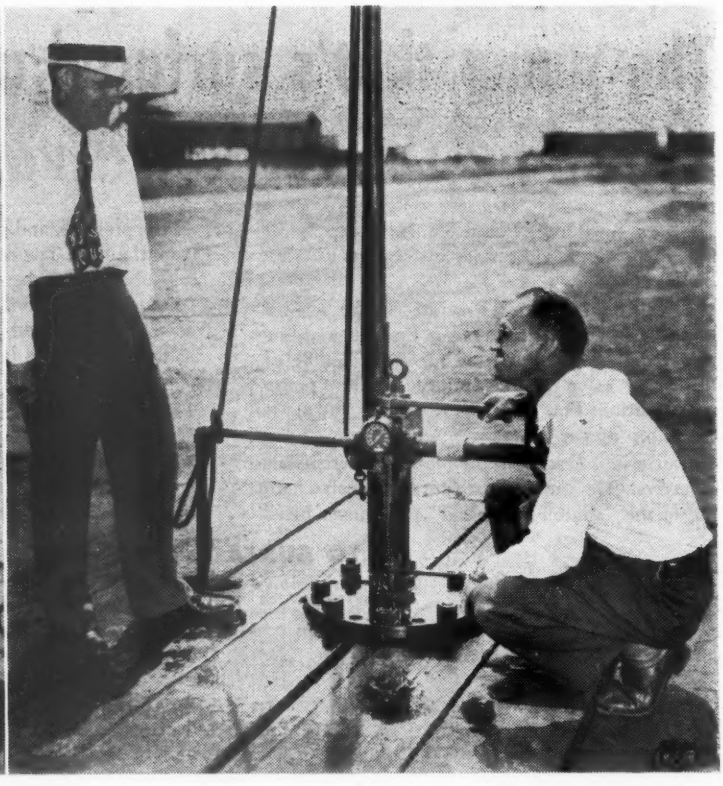


This is close-up of the nose of the packer assembly, which slides into pump catcher when the pump surfaces. The catcher is shown immediately above the pump. For the purpose of the photograph, the pump is being prevented from sliding down the power tubing by a wrench. Upon being released, the pump disappeared down the tubing, being prevented from falling by column of oil standing in the tubing. Pressure of power oil, directed down the tubing, is required to force the pump to seat properly.



With pump catcher in place, O. W. Flanders, head of Kobe's California Technical Service Department, turns the 4-way valve handle to "pump in" position. This directs the flow of power oil down the power tubing, forcing the pump to seat. In this well, which was slightly below 5000 ft, the seating time, beginning with the release of the pump at the wellhead, was a little less than 40 minutes. As soon as the pump seats it starts pumping oil. The pressure used to run the pump down the hole is the same pressure used to pump it on seating. Clarence J. Coberly, Sr., president, Kobe, Inc., standing.

ing is large enough to accommodate an inner string of the proper dimensions. The standing valve assembly in such instances is run in on the inner string sealing in the outer string shoe, already installed; or it may be adapted to any seating arrangement in the string.

There is a third type of installation—the casing type—that is similar to the concentric operation. It represents the maximum of efficiency and economy, and is applicable to those cases in which gas and other conditions allow casing type pumping. The power tubing in which the pump operates is run in with a standing valve assembly and anchored in a packer shoe. The casing annulus carries the production and constitutes the second limb of the "U" tube.

In all three systems the operation of the pump in the power tubing is the same. When seated, the O ring on the nose assembly forms a seal in the packer collar. This prevents the power oil from squeezing past the unit, and forces it into the engine end to actuate the engine and thence the pump. In general, the free pump functions in exactly the same manner as the conventional hydraulic pump, the only difference being that the conventional unit is lowered into the hole at the end of the power oil tubing and is attached to it. In this case it is necessary to pull the tubing to bring the pump back to the surface whereas with the new type the pump is moved up or down the power line without disturbing the tubing—so effortlessly that the pumper can be about more urgent matters after he has set the valve and while fluid power carries the pump silently up or down as circumstances require. It should be noted that when the standing valve opens at the seating of the pump the ball check is held off seat magnetically and remains so held until the pump begins its next journey to the surface. This permits production oil to be sucked up by the pump and at the same time greatly reduces the possibility of wear by minimizing the movement of standing valve parts.

Clean power oil is required for satisfactory operation and since the power oil tubing is not disturbed nor exposed to atmospheric corrosion or sand abrasion and since also each pump trip wipes the tubing walls cleanliness is correspondingly easier to maintain. Prior to each pump running the system is circulated to insure the absence of grit or other deleterious agent in the power oil tubing.

Looking at this interesting development even with a hypercritical eye there seems to be justification for the contention that by eliminating the normal expense of pump pulling for repair and replacement, free pumping lowers overall pumping costs considerably. The extent of this lowering will depend of course on many factors but there is no question that the cost curve is bound to trend in a downward direction when general conditions are amenable to the installation of free as opposed to static units. Such an installation renders simple the matter of adjusting capacity and speed of pumping to changing downhole conditions. It provides an opportunity to use the right size pump for each well and changing pumps is such an elementary process that it lends itself definitely to greater flexibility of operation and in other respects promises the maximum of economy.

The entire free pumping operation is so lacking in complexity that even after one is thoroughly familiar with the involved mechanics there is still a tendency to warn the pumper that if he doesn't watch out he is going to drop that pump down the well. When he actually does drop it down the well, purposely and with full understanding of the consequences it takes quite a little strength to refrain from saying, "Doggone it—I told you what would happen!"

In a decidedly push-button-conscious age, this is probably as near as anyone has yet come to instituting a push-button era of well pulling. ★★★

New counter-current reflux still

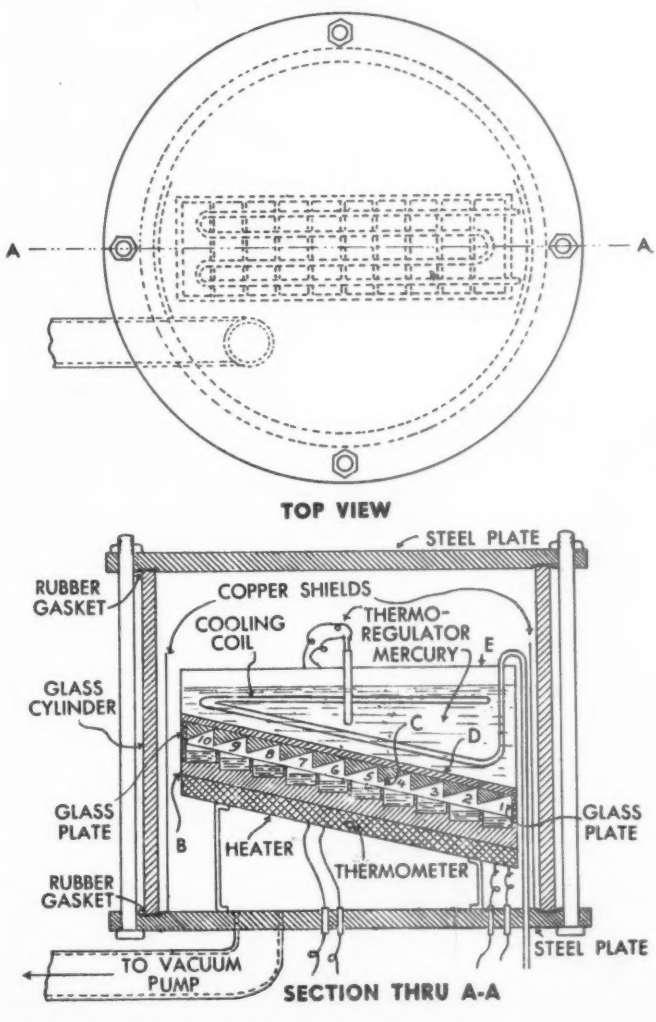
A NEW and highly efficient type of countercurrent reflux molecular still for the separation of natural isotopes has resulted from wartime research at the National Bureau of Standards with the cooperation of the United States Department of Agriculture. During the course of the work, several modifications of the apparatus have been developed in connection with research on mercury isotopes.

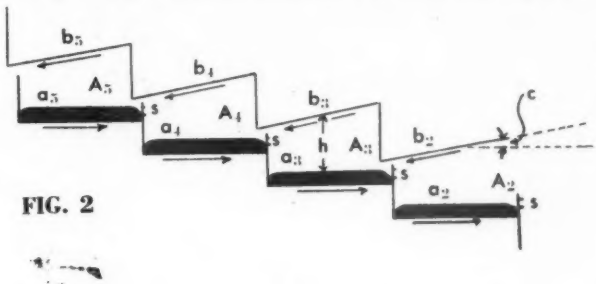
The discovery of practical means of obtaining isotopes provided the chemist and biologist with a powerful tool—known as the method tracers—for the study of chemical processes, particularly those that take place within the living organism. The method of tracers uses an isotope of a given element as a "tagged atom," which may be traced through a series of chemical reactions without loss of identity. Now that quantities of previously rare artificial radioactive isotopes are available, because of recent discoveries in nuclear physics, the progress in their utilization as tracers can be greatly expedited; however, for many applications of this method the stable, naturally

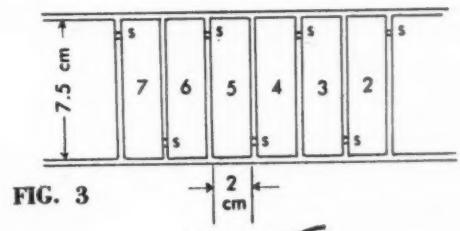
FIG. 1. Diagram of a 10-cell cascade system at the National Bureau of Standards for separation of mercury isotopes by counter-current reflux molecular distillation. The evaporating reservoirs (2 cm wide, 75 cm long, and 0.8 cm deep on the shallow side) were machined from the iron plate B and are heated by a nichrome coil imbedded in an alundum plate bolted directly to the reservoir block. Spillovers (S, Fig. 3) were cut at alternate ends of adjacent cells to provide thorough mixing of the liquid. The over-all effect is to concentrate the lighter isotopes in upper and heavier isotopes in lower cells.

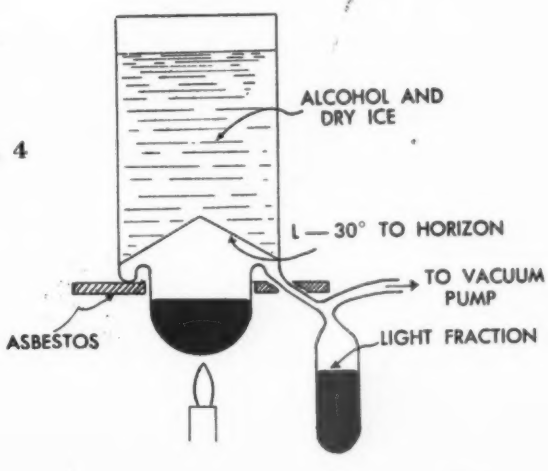
FIGS. 2, 3, 4. The mechanism of operation of a multistage molecular still is shown in Fig. 2. The vapor rising from the surface a3 of the liquid in cell A3 condenses on the sloping surface b3 and runs down to drop into the adjacent cell A4 higher up in the series. At the same time the liquid level in cell A4 is kept constant by means of a spillover S, which allows the liquid to flow back into cell A3. Lighter isotope is concentrated in the uppermost cell while heavier isotope collects in lowest cell. The same arrangement is viewed from above in Fig. 3. A single-stage glass molecular still is illustrated in Fig. 4.

FIG. 1









Thank you, Leonard!

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occurring isotopes of a given element is required. The countercurrent reflux still has proved to be an effective instrument for the separation of the natural isotopes of mercury, and is expected to have application to isotope work on other elements. Meanwhile, plans are being made for the application of this type of apparatus to the separation of pure hydrocarbons from petroleum and the isolation of vitamins from animal and vegetable products.

The term molecular distillation has been applied to that type of distillation where there is no return of escaping molecules to the evaporating surface. This is accomplished by operating with high-boiling (low-vapor-pressure) liquids under such high vacuum that the mean free path of the escaping molecules is of the order of the distance between the surface of the evaporating liquid and the cooled condensing surface of the still.

In molecular distillation, the relative rates of escape of the various types of molecules from a composite liquid surface are determined by two factors: (1) The vapor pressure (or the boiling point) of each component, and (2) the average molecular velocity of each component. Vapor-pressure differences among the isotopes of the heavy elements are small or nonexistent, whereas molecular velocities, at a given temperature, are inversely proportional to the square roots of the atomic weights. Molecular distillation thus offers a very practical means not only for separation of the isotopes of the heavier elements but also for the separation of any mixture of high-boiling substances differing in molecular or atomic weight. The latter application is particularly useful in the separation of hydrocarbons that do not differ appreciably in boiling point or are unable to withstand the high temperatures of ordinary distillation.

Previous work on the separation of mercury isotopes, using small single-stage molecular stills, has had little practical value because of the labor involved, the time consumed, and the large quantity of mercury required. In order to obtain appreciable concentration it is necessary to repeat the process many times. This requires an elaborate system for collecting, recombining, and distilling fractions. If this is not done, a tremendous quantity of mercury would be necessary to separate even one gram of a single isotope.

To overcome these difficulties, a new type of molecular still was designed in which a number of single-stage stills are so connected that recombination of fractions takes place automatically by gravity feed. In this way, the necessity of making repeated "cuts," with consequent reduction in output, is eliminated. The resultant separation, realized in one operation, is equivalent to the separation per stage raised to the power of the number of stages. As a result, the time and labor involved become much less than for repeated distillation in a single-stage still. For example, a separation that would have required 55 individual and recombination distillations was obtained in one step with a 10-compartment still. In addition, the quantity of mercury required is enormously reduced.

The multistage molecular still consists of a series of evaporating surfaces, or pools, set adjacent to each other but at slightly different levels. A cooled roof directly above each pool services to condense the vapor. The roofs are so sloped that the condensate will run along the surface to fall into the adjacent cell higher up. Each pool is equipped with a spillover, which allows liquid to run back in amount equal to the condensed vapor carried forward. The overall operation is such that the light fraction increases in concentration toward the upper end, whereas the heavy fraction increases in concentration toward the lower end of the still.

In addition to the great savings of time, labor, and materials effected through the use of this still, there are further advantages. The operation can be made continuous; the material to be concentrated can be fed into the system at one end or at the midpoint, if both light and heavy fractions are of interest; and the concentrate can be withdrawn continuously. Furthermore, the entire separation can be run without exposing the material to the atmosphere. This is particularly desirable for liquids that are susceptible to decomposition upon exposure to air. ★★★

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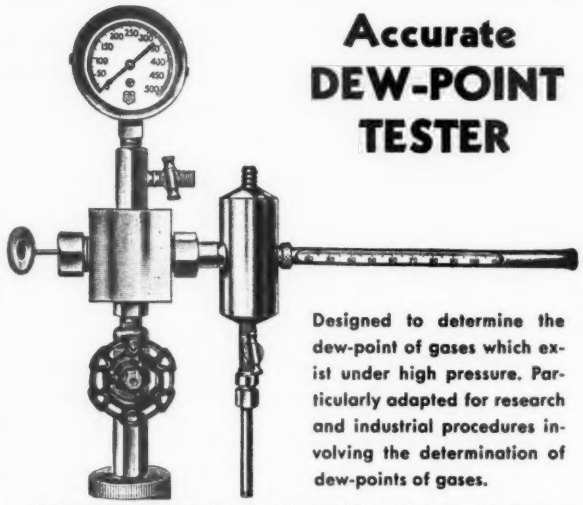

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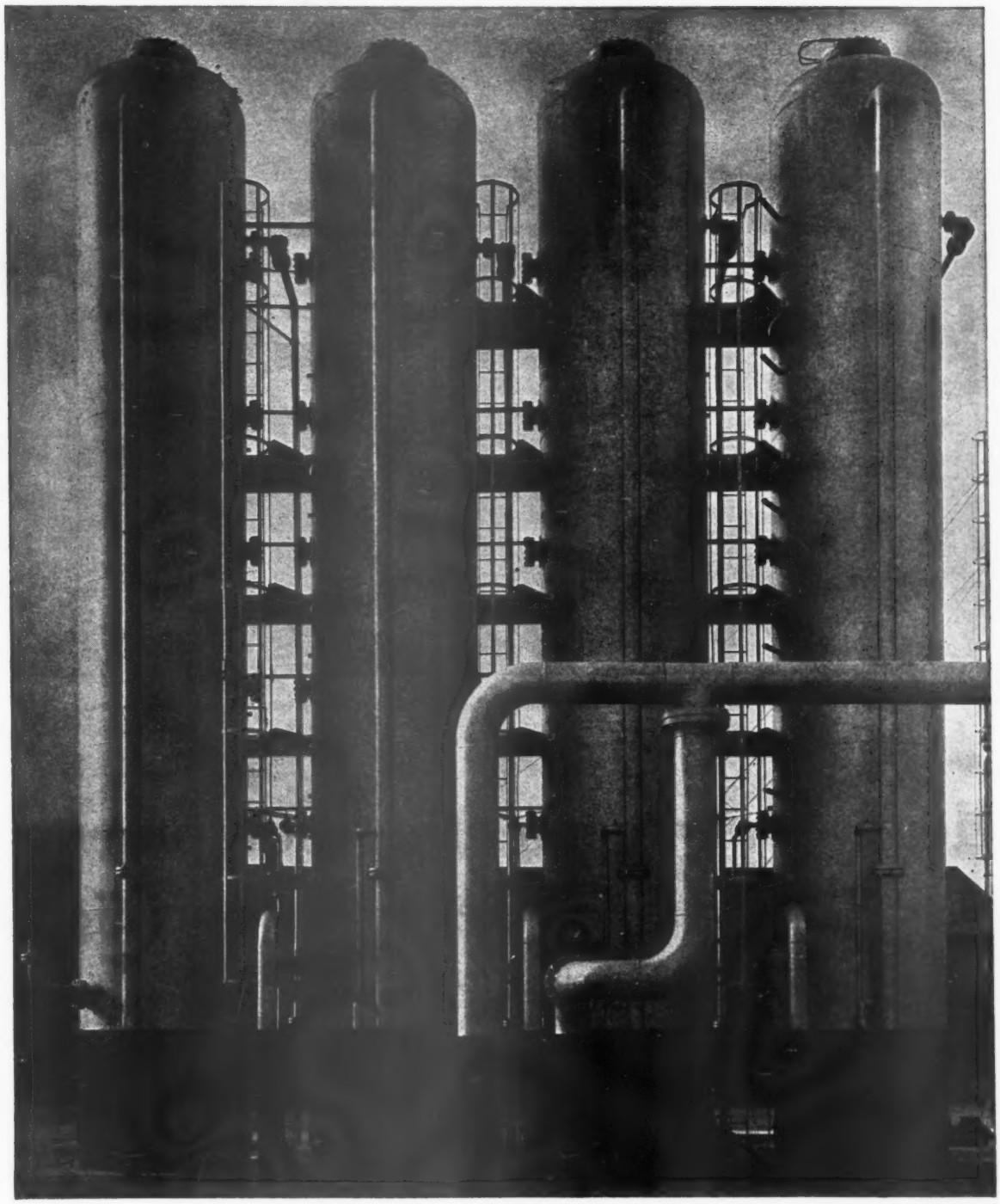

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Aerial view of cementing unit showing measuring tanks, pump, auxiliary engine, and screw conveyor.

Heavy duty cementing equipment performs wide variety of operations

By NICHOLAS A. D'ARCY, JR.

A NEW piece of cementing equipment has been developed[1] that can be moved to the drilling location where it will perform any known cementating operation without assistanoe from the drilling equipment at the well. The pump has been tested to pressures just under 12,000 psi when in operation on the truck and when driven with its regular equipment. It will displace more than 20 gpm at pressures in excess of 9000 psi, and more than 250 gpm at moderate pressures.

EXCLUSIVE

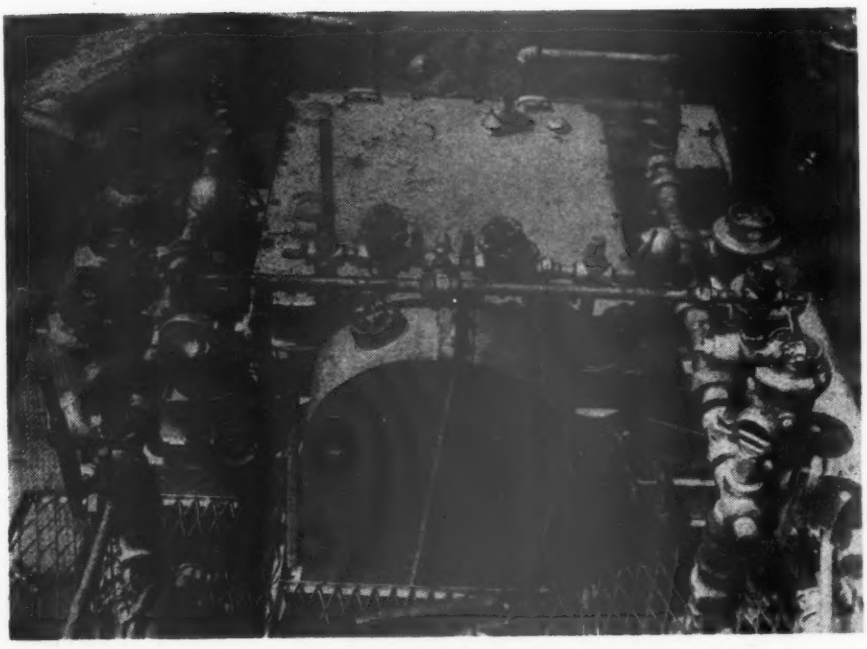
● **Prime mover.** The unit includes three major items that have been assembled to produce an unusual new piece of cementing equipment. The prime mover is a 1090 cu in. gasoline engine that is rated at 300 hp at 1800 rpm. This engine drives the special truck through conventional transmission and rear end. The power is diverted to the pump through a special power take-off[2] that is capable of transmitting continuously full horsepower. One of the interesting developments in connection with this engine was the construction of an air-cooled exhaust, which reduced the manifold temperatures to a safe operating temperature. This manifold includes a sheet metal shroud around the exhaust manifold itself, through which air is forced by the engine fan. The air cooling is also carried to the final exhaust where the velocity of the exhaust gases induce an upward circulation of air around the final tubing and muffler. An oversize cooling fan is used on the truck to insure adequate engine cooling while operating at high output capacity as a stationary engine.

● **Torque converter.** Of interest, also, is the hydraulic torque converter. This unit is driven at full engine speed at all times through a special power take-off and then through a conventional truck drive line. The converter provides a means of obtaining a wide variety of pressure-volume relationships from the pump and also a means of holding any required stall pump pressure for long periods of time. The converter will provide output torque in ratios from 1:1 engine to 5:1 engine torque with corresponding increases in pump pressure for corresponding pump speeds.

A special right angle drive has been built into the torque converter and it drives a large multi-blade fan for cooling the converter fluid. The fluid is circulated through four torque converter fluid cooling radiators and this combination of large radiator capacity and over-

[1] By International Cementers, Inc.

[2] Developed by the Republic Supply Company of California.



Close-up of six-cylinder plunger type cement pump capable of circulating fluid at more than 10,000 psi.

size cooling fan makes it possible to run the converter under all operating conditions without overheating.

● **Pump.** The cement pump was developed for this particular job. It is within the 8-ft road width, is light in weight, high in volumetric capacity, and was built to produce extreme pressures at extremely slow speeds. The construction is of the plunger type with the six plungers operated through Scotch yokes. The plungers are in banks of three and either bank of three can be operated independently of the other. This provides for a means of increasing the possible pressure with a reduction in circulating volume. The stroke of the pump is 7 in. with three 4¾-in. diam plungers and three 3½-in. diam plungers.

● **Pumping characteristics.** The pump has been observed in the field operating at speeds in excess of 100 spm when pumping at a pressure of approximately 200 psi. This results in a cement displacement of 250 gpm. As the pressure requirements increase, the torque converter output speed will decrease but a maximum relationship between possible pressure and volume will be maintained automatically by the action of the torque converter. The accepted method of operating this equipment is to utilize all six cylinders until approximately 4500 psi pressure is developed. Should small volumes be required at slightly greater pressures the torque converter provides them at reduced pump speeds. If very high pressures are to be encountered only the 3½-in. plungers will be cut into the pumping circuit and it is then easy to exceed a pressure of 10,000 psi. The combination of torque converter and ability to use either three or six plungers provide for extreme flexibility in the pump. The converter also makes it practicable to obtain and hold any desired pressure, under the maximum obtainable, by merely operating the engine throttle. If the plugs are set or if circulation is plugged, the operator will gradually open the engine throttle and watch his pressure gauge. As the throttle is opened the pump will remain stalled but the pump pressure will build up. This build up of pressure will continue until circulation is broken, the maximum desired pressure is obtained, or until the pump is operating at full pressure of better than 10,000 psi. No operator has yet asked for more pressure than this unit can develop at partial throttle.

● **Auxiliary equipment.** A Ford engine is mounted on the rear platform of the cementing unit to provide power for the auxiliary equipment, including the mixer and conveyor. This engine drives the fluid pump, which in turn drives fluid motors. The cement screw conveyor that elevates the bulk cement to the mixer is driven by one of these fluid motors, as is the cement and water mixer. The main truck or cement pump motor throttle is also mounted on the rear of the truck. The operator stands at this position while cementing a well and he is able to control all mixing and pumping down operations from this point. The fluid motor on the cement conveyor and the water proportioner are both placed in such a manner that the operator can control positively the proportion of water and cement at all times. After being mixed the slurry discharges into a pan at the operators feet where he keeps it under constant observation.

Large bulk cement trucks are used to deliver cement to the well and they are equipped with screw conveyors that screw the bulk cement directly into the conveyor hopper of the cement pump truck. Bulk trucks provide the rapid and controlled supply of cement to keep cementing operation constant.

● **Cementing jobs.** This large equipment has been used on many types of cement jobs from 1200 sack casing jobs to 25 sack water shut off jobs and it is able to do them all effectively. This equipment helped with Pacific Western's one-time world's record National Royalties No. 1 well when it cemented 16,406 ft of 5½-in. casing using 1200 sacks of cement. The work had to be done rapidly and surely due to the high bottom hole temperatures. The bottom hole pressure was so great that 115 lb per cu ft cement had to be used followed by 130 lb per cu ft mud.

Another operator in the Ventura deep zone had to set a deep whipstock, which required but 30 sacks of cement, but he also required a very hard plug for diverting the whipstock. The new cement unit did this job by mixing and pumping down 30 sacks of construction cement, which was mixed with 7 sacks of sand. The mixing was done in the truck conveyor and mixer and the pumping of the sand was done without damage to any of the equipment. Pressures encountered on this job were slightly in excess of 1100 psi.

Air-cooled exhaust brings truck manifold and exhaust gases to safe operating temperature.

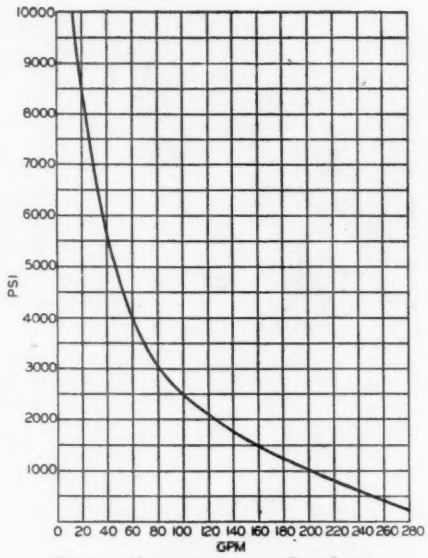
In the same field a remedial job was done with this type of equipment. The first operation was to reverse circulation and determine at what pressure the formation would break down and begin to take fluid. This operation is done easily and surely through the operation of the converter drive. The cementer pumped until the hole was full then gradually opened the throttle while the pump remained stalled. On this particular job the formation broke down when a pressure of 4500 psi was developed by the pump. At this point 25 sacks of high temperature cement was mixed and displaced into the formation followed by 5 cu ft of water, which was in turn followed by 305 cu ft of mud. This was then squeezed at a pressure of 6500 psi. All this material, cement, water, sand, and mud, were displaced through the pump. On several of the breakdown tests in this area pressures in excess of 6500 psi were developed without breaking down the formation and the operators did not apply greater pressures for fear of damage to the casing. The equipment operated at partial throttle under extreme conditions and performed these test operations smoothly and without violent impact loads on the equipment or casing.

A field in the Castiac area is producing from one zone and injecting gas into zones immediately above and below the producing zone. Cementing jobs in this field are most difficult and they are often figured down to a half a sack of cement. The new cement unit has such accurate control of volume that it is at a premium in water shut off jobs in this field. On a recent job requiring 24 sacks, the operator completed the job with 24 sacks and 20 lb of cement.

A job in the Los Angeles Basin required the addition of 3 per cent gel to the cement when displacing 225 sacks of cement on a surface casing job. This material was easily added to the cement and mixed in the regular truck mixer on the new truck or it could have been added to the bulk cement while loading at the bulk plant.

● **Special jobs.** Another job performed on the deepest well in California was circulating heavy oil while trying to free stuck drill pipe. The pipe was stuck below 16,500 ft and the new equipment was moved in to provide positive control of the oil when it was pumped.

A circulating job in Ventura required 749 hr of operation by this special cementing equipment. The unit was used to recondition a well and bring it back on production and the work covered many phases of pumping operations, all of which were handled by the new equipment. One of the first operations was to mix Baroid with Black Magic drilling fluid and circulate it in the well in an effort to free stuck tubing. The mixing of Black Magic and Baroid was done by the regular equipment in the truck conveyor and mixer and pumped directly into the well. No special mud pit nor other mixing equipment was required.



Range in pressure and volume obtained with modern high pressure cementing equipment.

The heavy fluid was followed with 60 bbl of black oil, which was spotted at the point where the pipe was stuck and later more Black Magic was displaced into the well. After freeing the pipe the black mud was displaced with water and the water was then displaced with 300 bbl of clean oil to bring the well back on production. All these fluids were handled with ease through the plunger pump and maximum pressures of 2800 psi were encountered.

● **Scope of jobs.** The new heavy duty cementing equipment has been used effectively on jobs of almost every type. It will mix 1200 sacks of cement on casing jobs in approximately half an hour and yet the same equipment is used for delicate jobs requiring displacing of less than 25 sacks under the most exacting conditions.

The pump will handle cement slurry and also all the other materials used in cementing and repair of oil wells. Cement, sand, oil base mud, clay base mud, water, cement, and gel are among the many products pumped with this equipment.

The unit has never been called upon to exert its maximum pressure on any job. The torque converter provides the cementer with an easy means of providing the exact pressure required for any squeeze or break down of formation job without exceeding the desired pressure.

● **Conclusion.** The International Cementers' new 6-cylinder pump driven through a torque converter and by a prime mover of adequate horsepower is the result of three years' development and field experimenting with this type of equipment. The present unit shows the result of the careful field work and many changes in arrangement that were required to bring this combination of equipment up to its present efficient stage. ★★★

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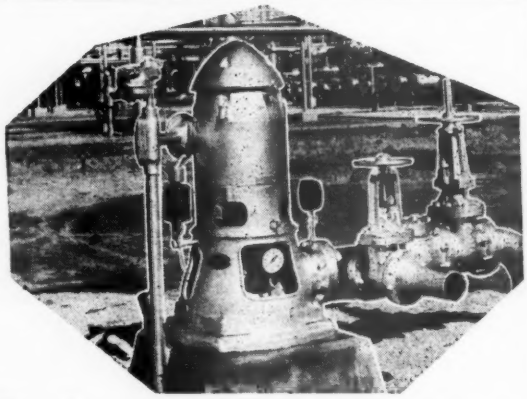

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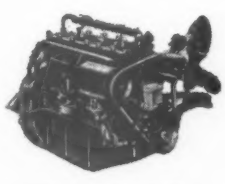

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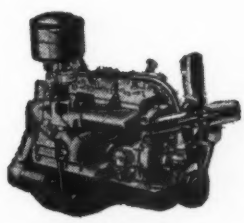

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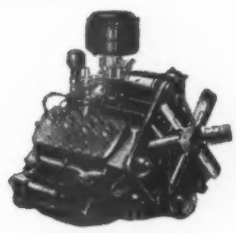

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By W. G. TAYLOR, Industrial Engineering Divisions, General Electric Company

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EXCLUSIVE

In water flooding, water, which is usually treated, is injected by gravity or under medium or high pressure into the oil sand of the producing field. The water forces oil into adjacent wells from which it can be recovered by flowing or pumping.

● **Water flooding requires an adequate water supply.** Although surface water can be used on some leases the usual water supply is a deep well from which the water is lifted by pumps or sometimes by compressed air.

Motors for deep well centrifugal water pumps—generally known as turbine pumps—are usually vertical squirrel-cage induction motors. Motor sizes range up to about 125 hp, usually at 1800 rpm. Not only are high-torque motors unnecessary, but their efficiency is somewhat lower.

Motor-driven compressors are required when air lift is used. This method of supplying water is far less frequently used than deep well centrifugal pumping. Although the first cost of equipment for air lift is less the efficiency is low because the compression heat is lost. Air lift may have considerable appeal for supplying small amounts of water because of the smaller investment but the formidably high power cost for large wells or for a large number of small wells cannot be ignored.

Motors up to approximately 15 hp are used for compressors. They should be high torque motors because they must start automatically against the full head of water standing in the wells.

All control equipment for water-flooding systems must be completely reliable. Two fundamental considerations govern the selection of control equipment for any motor in an oil field water flooding system:

(1) Shutdowns must be avoided, if possible, because they mean loss of production and possible damage to the lease;

(2) Simple, automatic operation shortens many unavoidable shutdown periods, lowers the labor cost per barrel, saves time, and reduces maintenance costs.

Constant speed induction motors are usually started at full voltage. Full voltage starting permits the use of inexpensive magnetic starters, which can be connected for automatic operation. If, for any reason, reduced-voltage starters must be used, manual rather than automatic starting should be seriously considered. Automatic reduced-voltage starters are more expensive than manual full-voltage starters.

Control of water well pump motors is effected by one of three methods:

1. A float switch or a pressure switch can be installed at the raw-water receiving tank. Pressure switches now in service are operating for tank depths of 8 to 15 ft.

2. A cycle timer (time switch) reduces the demand charge for power. When the pump capacity is more than sufficient for the field requirements, the pump can be shut down part of the time. Since the demand charge for electrical power is based on maximum 15-minute integrated demand, the greatest power cost saving will be effected if the pump is shut down for part of each 15-minute period rather than for part of a whole day. The time switch can be set to stop the motor before the end of each 15-minute period and restart it at the beginning of the next 15-minute period.

If the field requirements call for the operation of more than one well pump all may start and stop simultaneously or all but one may run continuously while that one runs intermittently.

3. Methods 1 and 2 can be advantageously combined. Float switch or pressure switch control alone does not maintain maximum and minimum tank levels. The advantage of combining the two methods is obvious. If the tank does not fill, however, before the time switch stops the motor the running period must be lengthened or additional pump capacity must be put into service.

If an electric power failure stops a deep well turbine pump the water standing in the vertical discharge pipe will rotate the pump backward unless there is a ratchet head or other non-reversing device. If power is restored during reverse rotation, the pump shaft may be twisted off. A time relay will prevent twist-offs by keeping the motor from starting until the pump has had time to stop running backward.

When air lift is used, the compressor motor control is exactly like the motor control for deep-well turbine pumps.

● **The water usually must be chemically treated and filtered.** For chemical treatment of the water, chemical feeder pumps are used. They are generally driven through a V-belt, by normal-torque, single-phase motors.

Agitators for mixing the chemicals are usually driven by motors of about ¼ to ½ hp. These motors are normal torque, single phase, right angle drive gear motors. The high speed reduction ratio permits the use of an inexpensive high speed motor to drive the low speed agitator.

Both feeder pump and agitator motors are usually connected to the load side of the water well pump starter, so that they start simultaneously with the water well pump.

For operation of the water filters, induction motor-driven filter pumps and backwash pumps are used. The filter pumps take water from raw-water tanks and pump it through the filters to the filtered-water tanks. The motors are automatically controlled by either float switches or pressure switches placed in the filtered water tanks.

The backwash pumps operate only when the filter needs cleaning. The motors are started and stopped manually.

● **The water is piped to the injection pumps.** Water pipe line and booster pumps are generally centrifugal pumps driven by squirrel cage induction motors. They usually run continuously. They are normally started and stopped by push button control.

These pumps must be protected against loss of suction pressure. A pressure switch, operating on pump-suction pressure, is adjusted to trip the motor starter when the pressure goes below the permissible minimum. In addition to protecting the pump, this pressure switch prevents the pipe line from filling with air. The switch can also be connected to sound an alarm, calling the operator who may not happen to be in the station.

● **The water is usually forced underground.** The pressure required to force the water underground may vary from gravity to approximately 1700 psi. In some areas the pressure averages about 275 psi; in others it averages as high as 1000 psi. The pumps that create the pressure are duplex or triplex reciprocating, or high-pressure centrifugals, with capacities ranging from 5 up to about 125 hp. The usual capacity in high-pressure areas is in the neighborhood of 40 to 50 hp. Centrifugal pumps can be driven by normal torque induction motors but reciprocating pumps need high torque motors for automatic starting against full pressure.

The motors are generally connected to the pumps through V-belt drives, because the V-belt drive permits the use of relatively inexpensive high speed motors. There is, however, a definite limit to the motor speed in relation to

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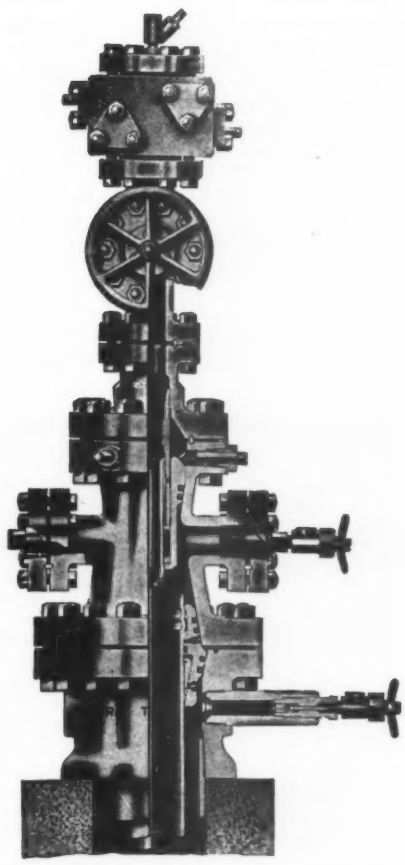

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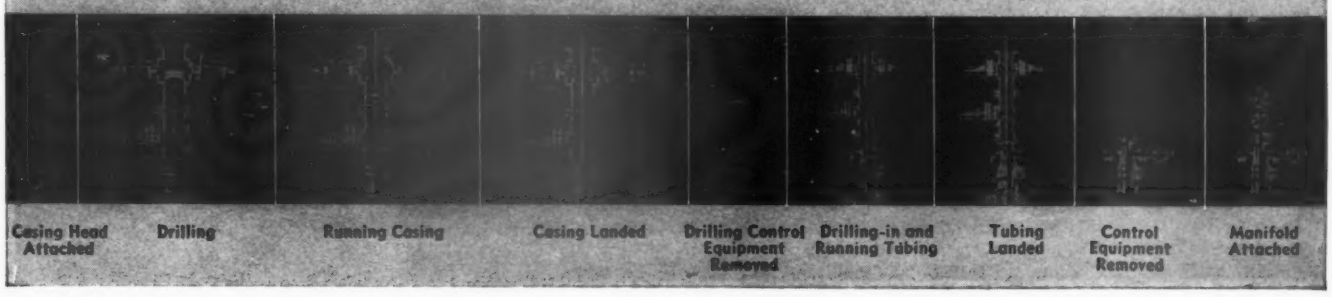


the motor size. The recommendations of the V-belt and electrical equipment manufacturers should be followed to avoid damage to motor bearings, motor shafts, and belts.

Control for injection pump motors usually consists of magnetic full voltage starters controlled by manually operated, contact-maintained control switches. These control switches are used instead of push buttons so that the starters can reclose automatically to restart the motors when voltage is restored after a power failure. Automatic restarting eliminates the delay that results when an operator restarts each motor by hand control. Manual control, however, is sometimes used and may be placed at the water-treating plant if desired.

In some installations, the simultaneous automatic restarting of a large number of pump motors will cause an excessive voltage drop due to an excessively high starting load on the power feeder. An increased demand charge may also result. In such installations, groups of two to four motors are started successively with a definite time delay relay controlling each group. The time delay is adjusted so that each group can accelerate to full speed before the next group starts. Starting the motors in small groups, in a multi-unit station, is particularly important when all the pumps are connected to the same suction manifold. It gives the water time to reach the pumps and it avoids the danger of collapsing the manifold. In a few installations two speed, variable speed, injection pump motors have been set up in the same station with other injection pumps driven by constant speed induction motors. When water injection is first started in a portion of a field, only a small percentage of the ultimate volume of water is required. It is supplied by the variable speed pump operating on its low speed connection. As the volume of required water increases the variable speed pump is speeded up correspondingly until maximum speed is reached. Then the pumping load is shifted to a constant speed pump and further load is gradually picked up by the variable speed pump. Although the flexibility of this type of control eliminates the need for bleeding excess water from the discharge, the electrical losses at reduced pump speed are considerable and the economy is questionable. Furthermore, the two speed, variable speed motor and its control equipment are comparatively expensive. The complicated control necessary to make the operation automatic would be impractical.

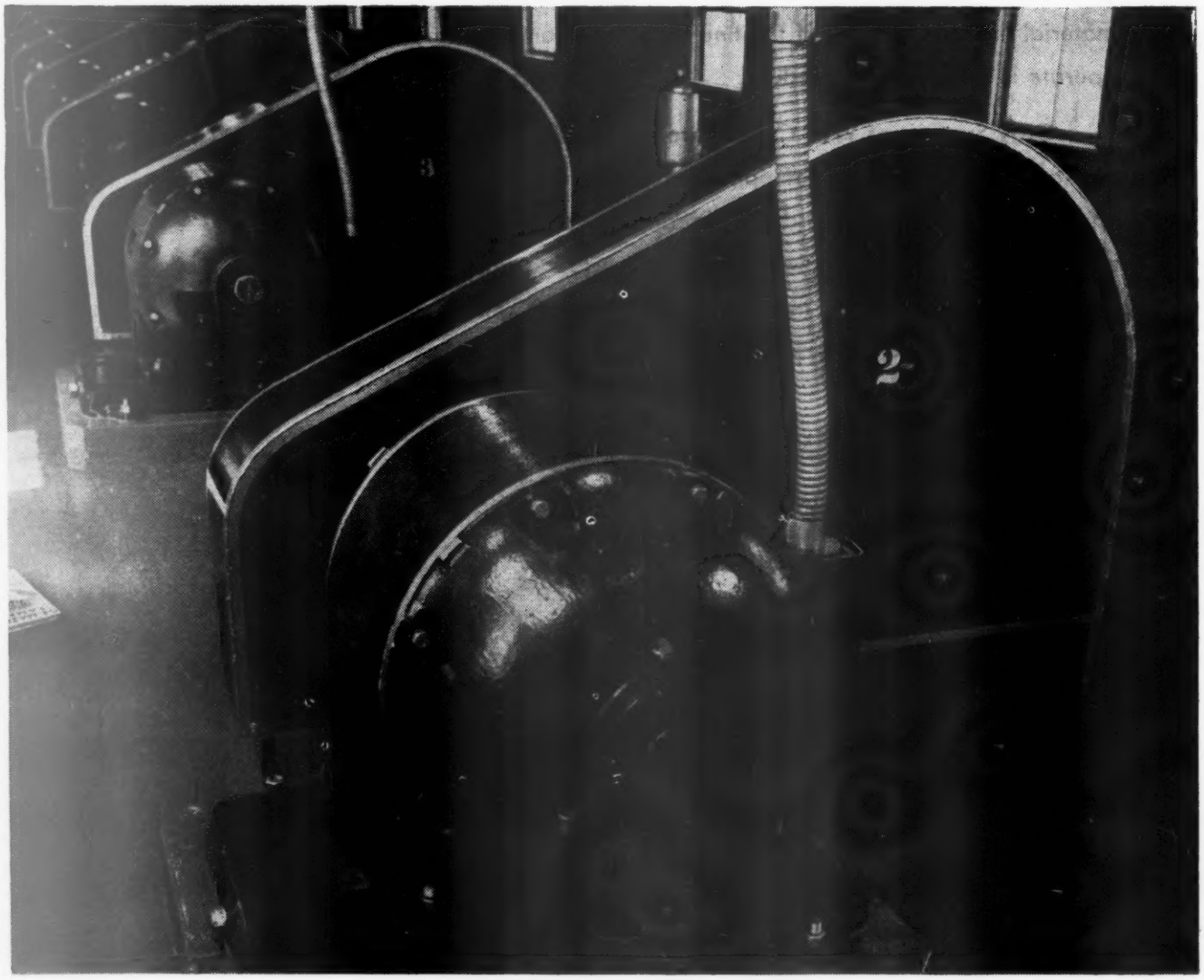
Oil well pumping in a water injection field does not differ materially from the methods used in other fields. Beam pumping and central power pumping are the methods most commonly used.

★ ★ ★

Explosion hazards of air and isobutane may be eliminated through introduction of nitrogen or carbon dioxide, the Bureau of Mines reports. Combustible air mixtures become harmless by the addition of 35 per cent carbon dioxide or 47.5 per cent nitrogen.

☆ ☆ ☆

Water-injection station with motor-driven pumps for water-flooding.



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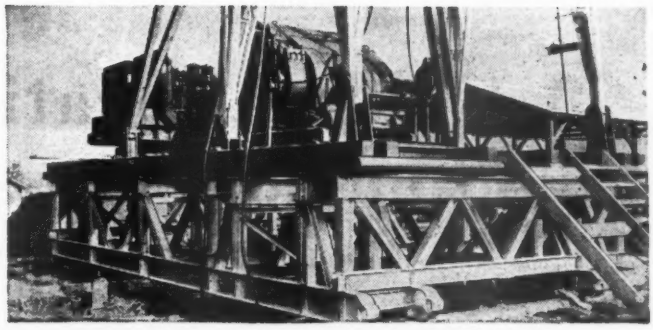

Two GM "Twins" drive this "Emsco" model 500 rig of the Drilling and Exploration Co.

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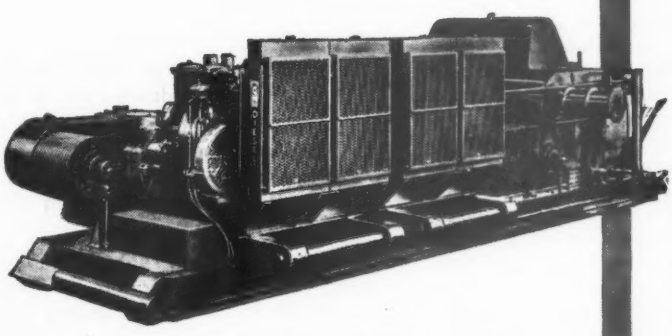
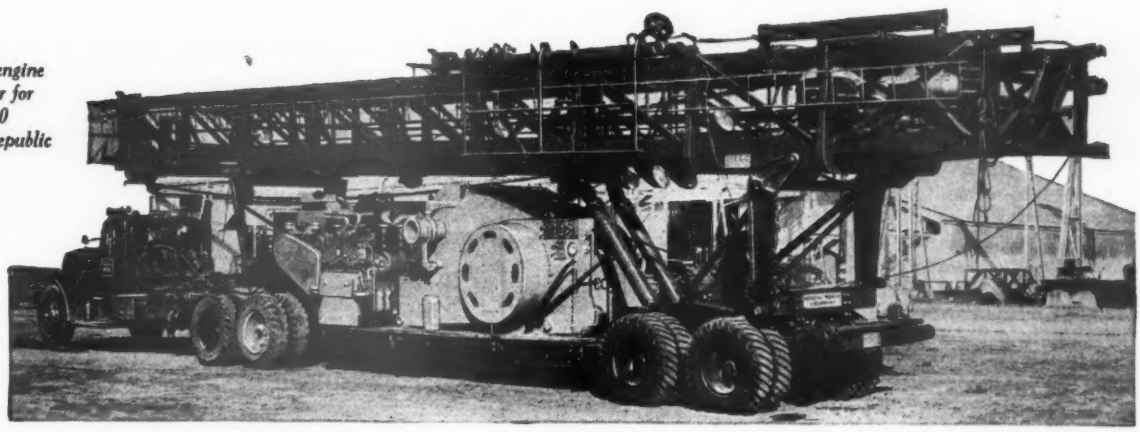


A pair of GM "Twins" compounded is the power for this "Unit Rig" draw works.

One GM "Twin 6" engine provides all the power for this "Ideco" model 40 portable rig, of the Republic Supply Company.



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A field calibration technique for bottom-hole pressure measurement*

By E. R. BROWNSCOMBE, The Atlantic Refining Company

● **Introduction.** New methods are being developed for analyzing reservoirs and predicting their behavior. These advances place increasing emphasis on precision in bottom-hole pressure measurement[1]. Thus early predictions of the extent of water drive depend upon a material balance estimate of the current water influx, and this in turn in an oil field may be seriously affected by whether the estimated reservoir pressure is slightly above or slightly below the bubble point. In a gas field the large compressibility of the reservoir demands high precision in pressure measurement if water influx is to be estimated early in the life of the field. Note that in general it is the *reservoir pressure* rather than the *bottom hole pressure* that must be determined. This places an added need for precision in bottom hole pressure measurement, for reservoir pressures are usually obtained by extrapolation of bottom hole pressure data. This paper evaluates the error of some factors in bottom hole pressure measurement and discusses a field calibration technique used in surveys for which particular precision is desired.

● **Errors involved in certain operations.** In an earlier publication[2] error reduction by use of a comparator microscope and by making multiple tests and calibrations were discussed in some detail, and interpretation errors involved in correcting for hydrostatic heads in the well and pressure gradients around the well pointed out. The data given herein include tests on the time required for the gage to come to temperature and pressure equilibrium, hysteresis in gage readings on increasing and decreasing pressures, and a study of possible errors of calibrating by applying pressure to the gage internally instead of immersing the gage in a pressurized bath. As previously, all tests were made on 1¼-in. Amerada gages.

● **Time required to reach equilibrium.** To determine the time required to reach temperature equilibrium, the cold gage was placed in a hot oil bath. A constant pressure was applied to the gage beginning before immersion in the bath. The apparent pressure was calculated from the gage modulus corresponding to bath temperature. Fig. 1 shows for one run the difference between the apparent pressure and the true pressure plotted against the number of minutes in the bath. It is seen that it required approximately 1 hr to come within 1 psi, while after 30 min the error was about 9 psi, and after 5 min the error was 48 psi. Table 1 shows similar data for other runs including one in which the gage was placed in nitrogen at 2000 psi in order to simulate conditions in a gas well. It may be noted that whether or not the oil was turbulent the results are about the same, suggesting that the primary heating lag is internal rather than external. In the case involving gas the time to approach equilibrium was about 50 per cent longer, but this may have been caused in part by the cooling effect of the gas as it was expanded into the bomb.

In actual practice a gage is in contact with heated oil as it descends in the well, so that many people feel that it will be essentially at bottom hole temperature by the time it reaches bottom. In order to check this, it was assumed that the temperature of the surrounding oil was rising steadily as the gage was lowered. This gave the following relation between gage temperature and time:

$$1 - x = \frac{k_1}{t}\,(1 - e^{-t/k_1})$$

In which:

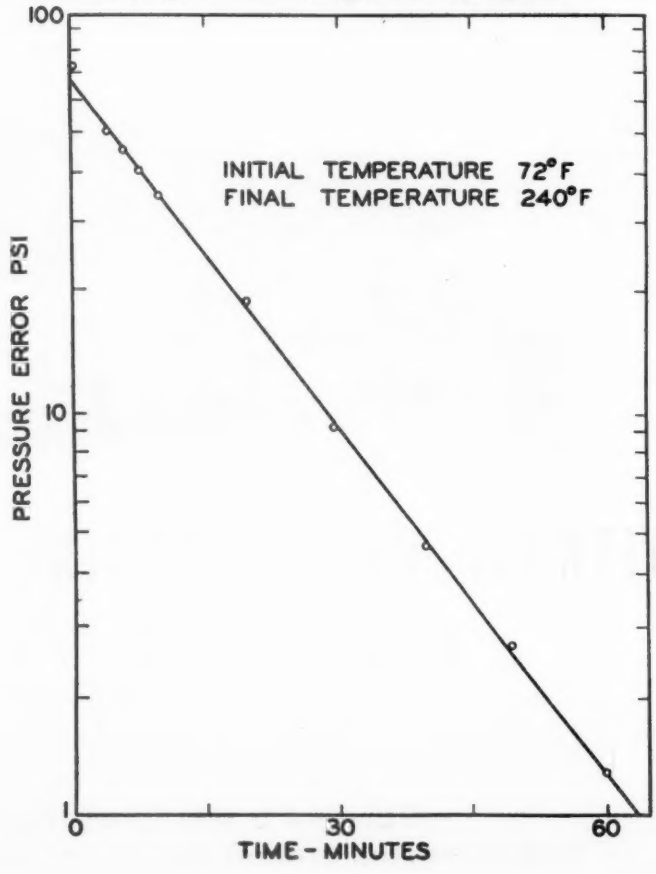
x = fractional temperature rise of gage, °F rise divided by °F differential between top hole and bottom hole temperature.

t = time to lower gage, min.

k_1 = gage heating constant, min (Table 1).

Taking k_1 as 14.9 (Table 1) and assuming that it takes 50 min to lower the gage 10,000 ft, the corresponding temperature rise being 160 F, it was found

FIG. 1. Time for Amerada bottom hole pressure gauge to attain temperature equilibrium.



*Presented before the Southwest Texas Section of AIME, April 10, 1947.

1. Perkins and Chaney "An Investigation of Errors in Bottom Hole Pressure Measurements," *Oil and Gas Journal*, June 14, 1947, p. 102.

2. E. R. Brownscombe and D. R. Conlon, "Precision in Bottom-Hole Pressure Measurements," *AIME Petroleum Development and Technology*, 1946, p. 159.

that the gage would be 46 F below the bottom hole temperature when it reached bottom. This corresponds to 10 psi error in pressure measurement. From Fig. 1 it may be seen that starting with this error, an additional 30 min at the bottom of the hole would have reduced the error to 2.5 psi. As indicated above, whether or not the oil was turbulent around the gage made little difference and even in a gas atmosphere the rate of heating was not greatly different.

The time required to come to pressure equilibrium when pressure is suddenly applied to a gage that is already at temperature equilibrium was also tested. Although several minutes were required for relaxation at atmospheric pressure, the gage came to within one pound of its final reading in less than one minute when pressure was applied. It is not clear why there should be this difference in time to reach equilibrium, but from a practical viewpoint it is unimportant in the well for the gage will always be at pressure equilibrium when sufficient time has been allowed for it to come to temperature.

● **Hysteresis.** Fig. 2 shows a hysteresis loop in which the original pressure indications as pressure is gradually increased to 3620 psi are compared with pressures indicated when the pressure was reduced to 3200 psi, increased to 3620 psi again, and finally reduced to atmospheric. All pressures were calculated on the basis of calibrations obtained on the original pressure increase curve. It is not surprising that a pressure reduction back to half the maximum shows the gage to be reading about 25 psi too high, but it was surprising that no indication of a loop was obtained when the pressure was dropped to 3200 psi and raised again. Both decreasing and increasing pressures over this limited range, which was run to simulate a drawdown test, followed the decreasing branch of the hysteresis loop. It is apparent that errors as great as 25 psi could be made in runs such as draw-down tests or well gradient test involving a pressure reduction on the gage. At higher pressures, greater errors would be possible. When using the gage in tests involving pressure decreases it will be necessary to calibrate it in a manner roughly following the expected changes.

● **Internal vs. external application of pressure.** Fig. 3 compares calibrations in which the pressure was applied internally through a screw fitting with those in which the gage was immersed in a pressurized bath. The construction of the gage suggests that there should be no difference, and the results show that the conventional calibrations using a fitting at the bottom of the gage give the same results as would be obtained if a pressurized bath were used.

TABLE 1. Time for Amerada gage to attain temperature equilibrium. Data taken with a 4500 psi element.

$$t = 2.30\, k_1 \log \frac{\Delta Pi}{\Delta P}$$

t = time, min.
ΔP = final pressure minus current pressure, psi.
ΔPi = final pressure minus initial pressure, psi.

Description of test		Temperature increase	Agitation of oil	Pressure error after 30 min, psi	k_1, min
Fluid	Pressure, psi				
Oil	2000	From 80 to 236 F	Quiescent	10	15.7
Oil	2000	75 to 240 F	Quiescent	9	14.1
Oil	2000	75 to 161 F	Turbulent	5	15.1
Oil	2000	72 to 240 F	Quiescent	9	15.0
		Average			15.0
Gas	2150	82 to 200 F		7	21.8

FIG. 2. Pressure difference in gauge reading caused by applying decreasing instead of increasing pressures.

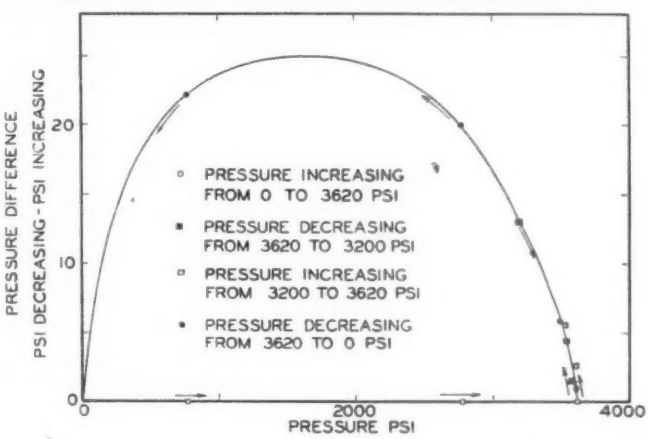


FIG. 3. Comparison of calibrations in open and in pressurized baths.

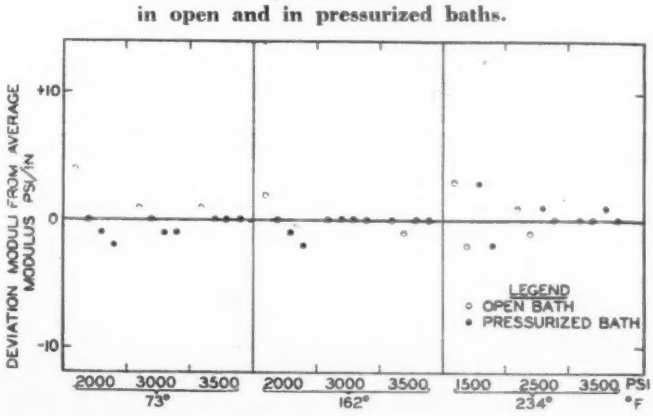


FIG. 4. Chart obtained when pressure measurement is bracketed by calibrations.

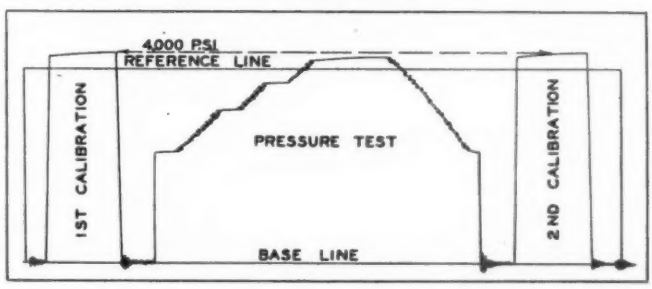


FIG. 5. Distribution of gauge errors.

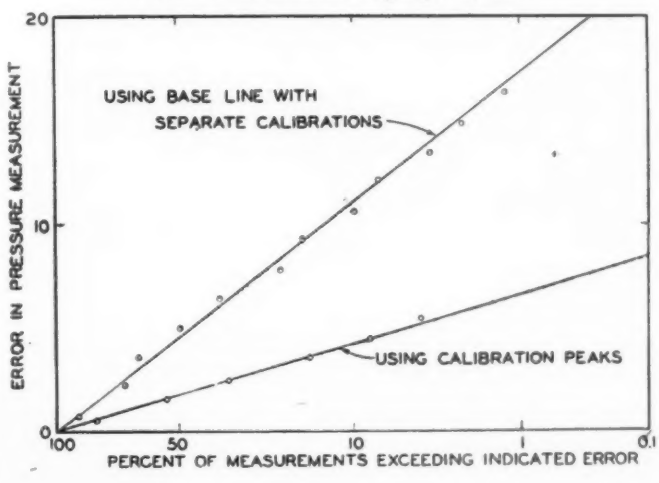


FIG. 6. Early use of field calibration technique with portable equipment carried in company car.

● **Field calibration technique.** In the field calibration method, both before and after each run into a well a calibration is made on the chart at bottom hole temperature using a pressure close to the expected bottom hole pressure[1]. Fig. 4 shows a typical chart. The arbitrary pressure reference line drawn by moving the stylus while the gage is still open is to aid in lining up the chart for reading, it having been found that such a line tends to be straighter and more reproduceable than the base line. Actual calculations are, of course, based on comparison of the bottom hole pressure plateau with the calibration plateaus.

This procedure has the following advantages over calibration at a central laboratory:

1. Calibrations on the same chart instead of different charts reduces the sets of readings involved in the pressure calculation from two to one, and reduces the random errors by approximately a factor of the square root of two.

2. Calibrations before and after the run give an accurate measure of the modulus of the gage at the time it is run, obviating the dilemma of choosing between calibrations that may differ considerably due to gradual changes occurring between the time of the run and that of the calibrations. Furthermore, the field calibration technique shows immediately whether a gage is operating satisfactorily during any run, and the large number of calibrations gives a close record on gradual changes in the gage.

Curves giving a comparison of the accuracy of the field calibration technique with the conventional method are shown in Fig. 5. It may be noted that only 10 per cent of the measurements had an error greater than 4.25 psi in the field calibration method whereas the conventional method showed 50 per cent exceeding this error or greater. The "conventional" method showed 10 per cent of the measurement exceeding 11 psi error. The "conventional" method refers to the use of periodic calibrations taken on separate charts read from the base line. The errors given for the "conventional" method were taken from the earlier paper cited above since no recent data are available. Current practice may be giving results that are somewhat better.

Note that where justifiable the random error can be reduced still further by going in and out of the same well several times.

The gradual development of the equipment is shown in Figs. 6, 7, 8, 9, and 10. Fig. 6 shows the equipment as it was originally set up. A portable dead weight tester, a collapsible oil bath, a butane heater, and sundry auxiliary equipment were carried around as necessary in company cars, it being necessary to set up and tear down the entire assembly for

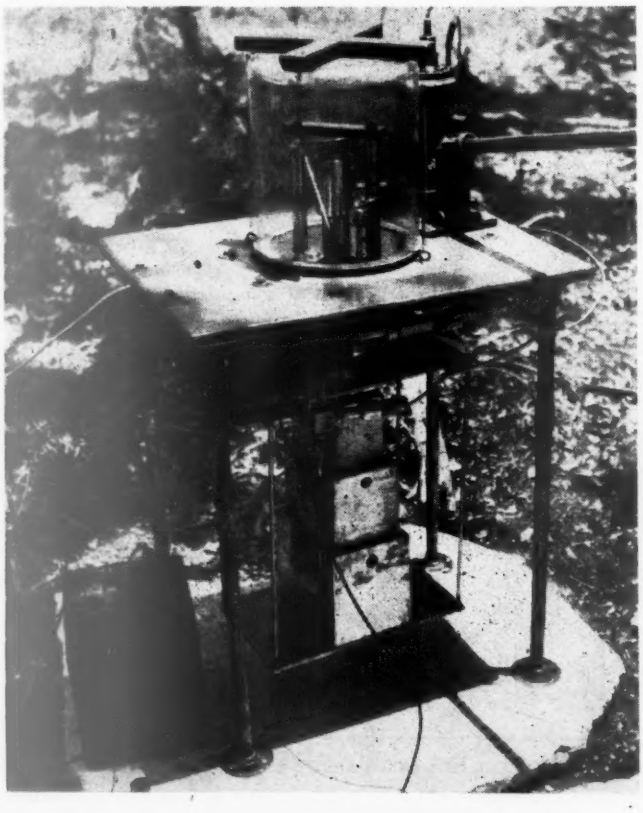


FIG. 7. Close up view of dead weight tester carried in company car.

FIG. 8. Pick up truck carrying mounted dead weight tester used while the pressure truck was being built.

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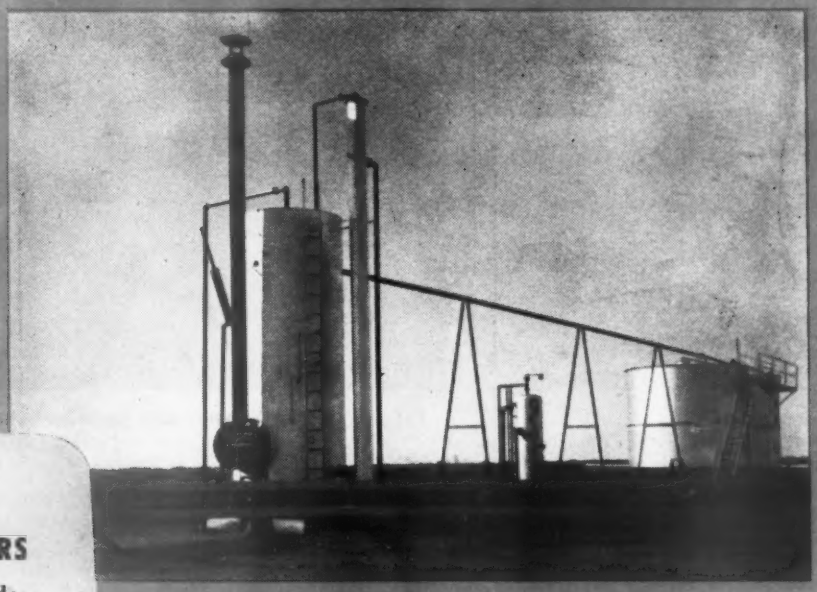

Type Y Emulsion Treater showing typical field hookup.

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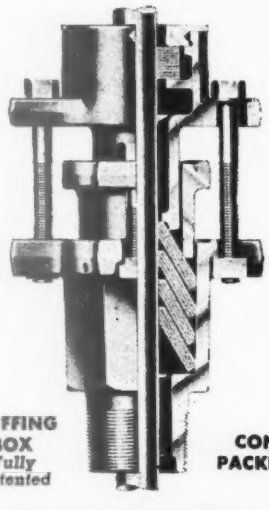

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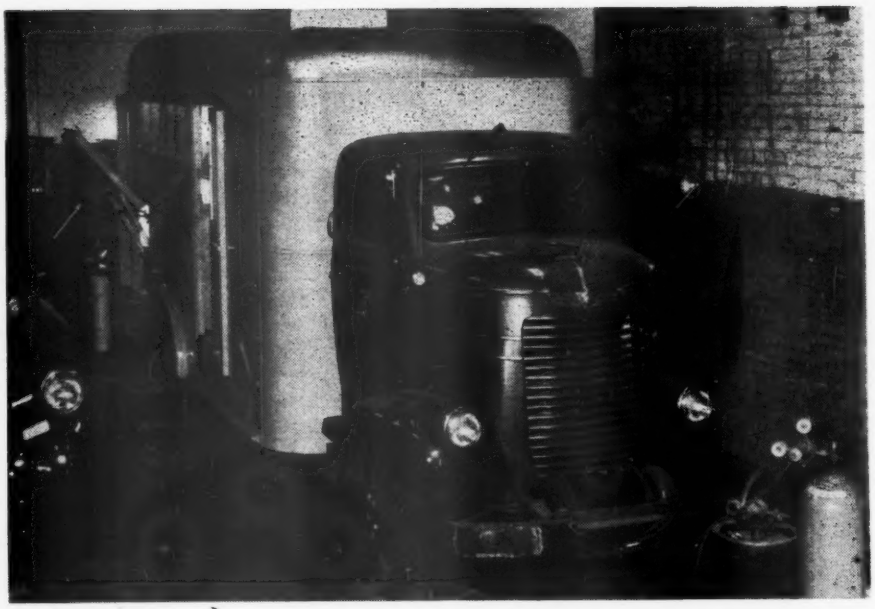

FIG. 9. Mobile bottom hole pressure laboratory in final stages of construction.

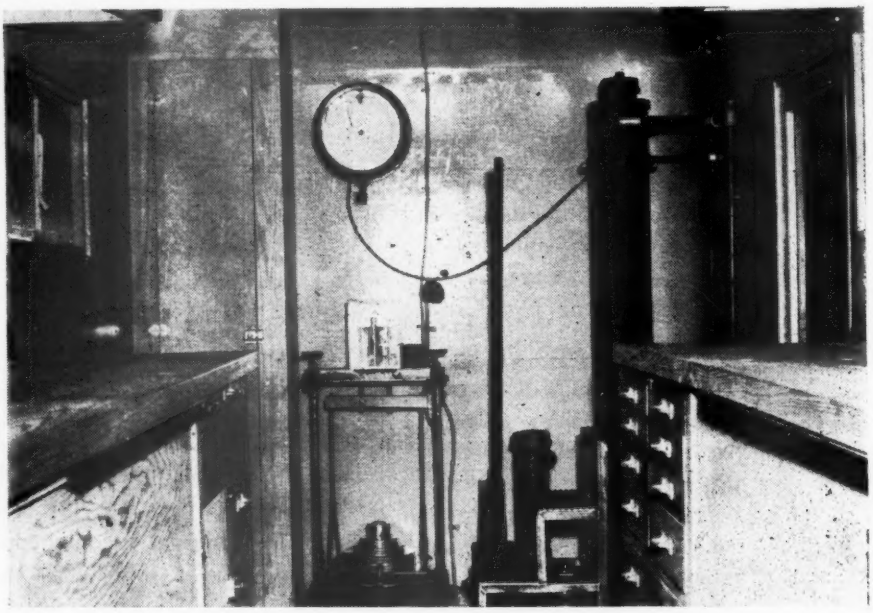

FIG. 10. Interior of bottom hole pressure laboratory.

each day or location. Fig. 7 shows in detail the portable dead weight tester, which was powered from the automobile storage battery.

It was then planned to install the dead weight tester and bath permanently in a truck and to provide a workbench, comparator microscope, etc., for the operator. Due to difficulties in getting a suitable truck, the equipment was first set up in a pick-up truck shown in Fig. 8. The dead weight tester was permanently mounted in the truck but the bath was set up at each location.

Fig. 9 shows a view of the mobile bottom hole pressure laboratory that is just being completed. The reel may be seen at the left side. Fig. 10 shows an inside view. The thermostated bath, which is heated with butane, is shown at the right rear. Power for the dead weight tester, which is shown at the back, and for lights, circulating oil through the bath, etc., is supplied by a generator. The recorder shown gives a rough record of the pressure applications. Space is provided for working on the gage, storing instruments, and reading charts.

● **Acknowledgment.** The author wishes to express appreciation to Mr. Orville Johnston for the careful handling of the many details involved in the laboratory work, and to Mr. V. E. Stepp of the Operating Department for his interest and cooperation in carrying out the field studies.

* * *

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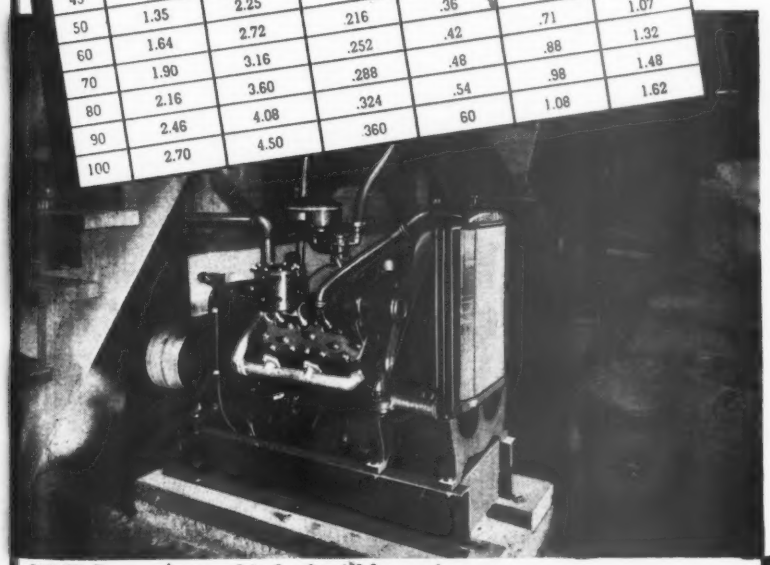
20	.54	.90	.072	.12	.25	.38
25	.68	1.13	.09	15	.30	45
30	.82	1.36	108	.18	.34	.51
35	.95	1.58	.126	.21	.39	.59
40	1.08	1.80	.144	.24	.44	.66
45	1.23	2.04	.162	.27	.49	.74
50	1.35	2.25	.18	.30	.54	.81
60	1.64	2.72	.216	.36	.63	.95
70	1.90	3.16	.252	.42	.71	1.07
80	2.16	3.60	.288	.48	.88	1.32
90	2.46	4.08	.324	.54	.98	1.48
100	2.70	4.50	.360	60	1.08	1.62



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By WILLIAM R. WILKINSON† and HAROLD A. BEATTY,‡ Ethyl Corporation

A PERENNIAL problem in fractional distillations is the accurate control of reflux ratio with a variable throughput. In the laboratory, manual control guided by visual observation of the flow is usually satisfactory. In pilot plant and larger installations this method is impractical and hence many contrivances have been devised and described for automatic division of the flow in a given ratio. These generally fall into two classes, the intermittent take-off and the proportional condensing surface type.

Carter and Johnson[3] describe a device employing a funnel moved magnetically; Brunn[2] uses a two-way valve and capillaries; Podbielniak[4] has an intermittently-opening valve seated in the take-off tube; Berg[1] describes a proportional condensing area device. Most reflux ratio controllers are difficult and expensive to build, contain delicate moving parts that get out of order, and are intermittent in operation or of such a nature that the ratio may be varied only by stages.

A proportional flow controller free from these defects has been developed in this laboratory and used successfully on a 5-in. diam column for one year. It operates on the principle of directing a downflow of liquid into a uniform, free-falling sheet or curtain that is split into two parts by a movable divider.

The device consists of an upper and a lower compartment separated by a horizontal plate, as shown in the schematic cross-sectional views of Fig. 1. This plate contains a narrow slot through which the entire liquid condensate flows by gravity, the liquid flow being indicated by arrows on the drawings. Just below and parallel to the slot is fixed a vertical sharp-edged guide plate that collects the liquid as a uniform falling film. The guide plate extends down into a movable tray having a vertical divider plate perpendicular to the guide plate; the arrangement of the slot, the guide plate, and the divider plate is shown schematically in Fig. 2. The divider plate has a sharp edge, and is notched to fit closely around the guide plate, so that it cuts the falling film into two separate parts, each of which flows out of one end of the tray into the lower compartment. That compartment in turn is divided on the bottom by a vertical plate, underneath the movable tray, which keeps the two liquid streams separated as they spill from the tray.

The dividing tray, which is supported on horizontal rails as shown, can be moved by a rod projecting through a packing gland in the side of the lower compartment, and its position is indicated by a pointer on the rod. The length of the tray, and the position of the divider plate, may be designed so that the flow can be split into any ratio over the required range, which can be anywhere between zero and total reflux.

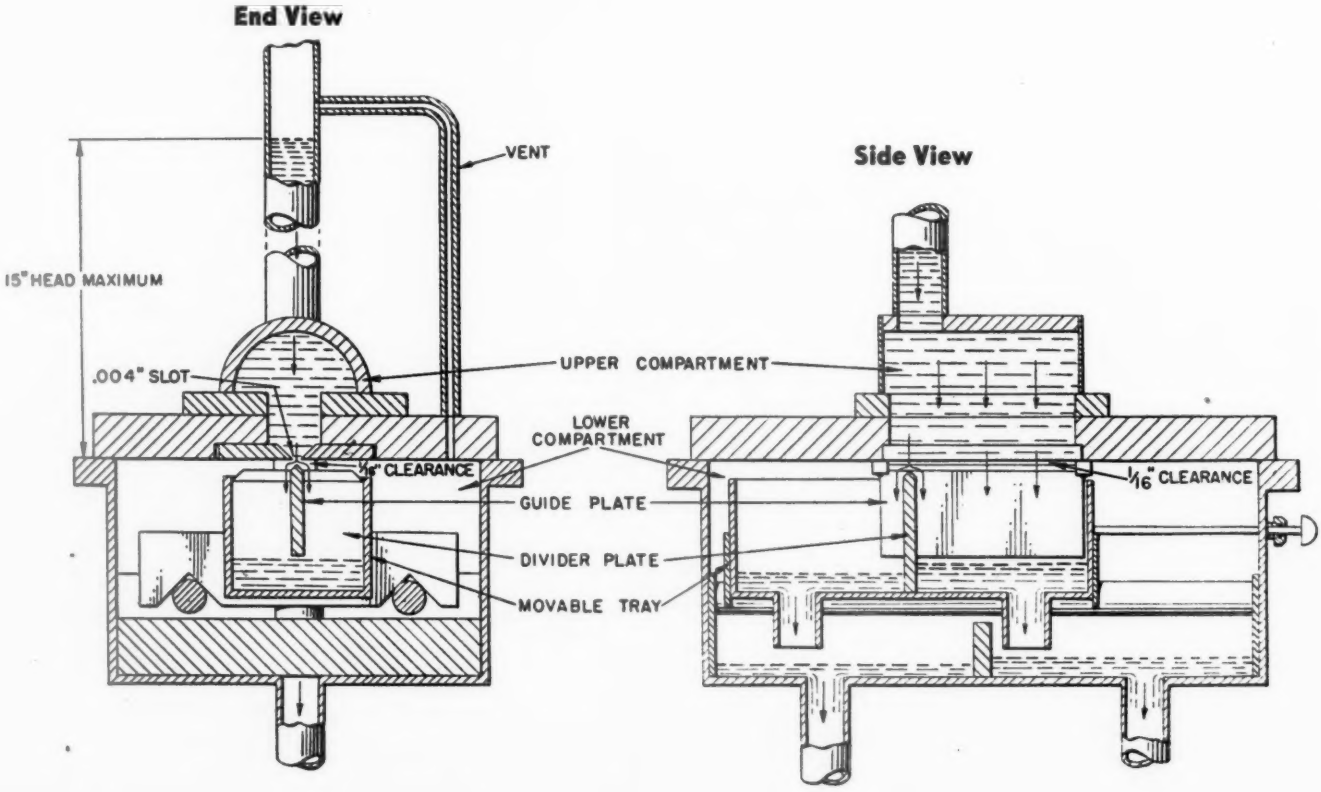
The liquid head in the upper compartment is determined by the input rate and slot dimensions, and the only variable in the liquid sheet leaving the slot is its velocity. Thus the instrument is independent of variations in throughput, within the limit set by the maximum available height above the slot. The upper and lower compartments are connected by vent lines, so that unequal gas pressures cannot develop. The vent from the upper compartment also acts as an overflow line into one end of the overflow compartment, in case the rate of flow

*First published in *Industrial and Engineering Chemistry*, 1946.

†Present address, R. T. Vanderbilt Company, East Norwalk, Connecticut.

‡Chemical Research Laboratory, Ethyl Corporation, Detroit, Michigan.

FIG. 1. Cross-section of flow controller.



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becomes greater than the capacity of the slot.

The guide plate below the slot maintains the continuity and uniformity of the falling film, and this constitutes the essential feature that makes the device workable. Without it, the velocity of the liquid will usually be insufficient to form a continuous sheet of its own accord. The slot itself is formed of two V-edged plates as shown in Fig. 2. The plates were made as shown because the edges must be parallel and straight, and with the soft brass that was used, this shape appeared to offer the best chance of obtaining these qualities. A thin hardened plate, ground to a sharp edge, would be at least as satisfactory, and probably better than the shape shown in Fig. 2. Although the direction of the V as shown does not make the slot self-cleaning, it is necessary to have it as shown in order to feed all the liquid to the guide plate. (A disk-type metal filter with low pressure drop was used on the feed line to remove any scale or sediment from the liquid.) With the exception of the slot, which must be fixed accurately, none of the dimensions are critical, and they may be varied to suit the individual requirements.

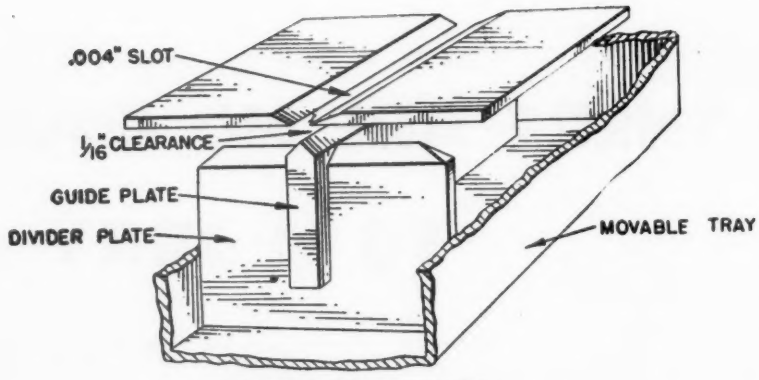

FIG. 2. Flow controller.

The plates are adjustable, so that the liquid head necessary to maintain the proper flow does not become unreasonable. The plates are adjusted at both ends, two feeler gages being used to ensure parallelism. The slot width is determined by the allowable liquid head and the density, viscosity, and surface tension of the liquid. A spacing of 0.0045 in. in a 4-in. long slot is sufficient to carry a flow of 5 to 25 gal of gasoline per hr at a maximum head of 15 in., and to provide a continuous sheet of liquid. This slot was tested with gasoline at reflux ratios in the range of 1 to 30. The ratios predicted from the position of the divider were obtained with an accuracy varying from ± 1 per cent at a ratio of 1 to ± 10 per cent at a ratio of 30, throughout the entire range of 5 to 25 gal per hr. This degree of precision is entirely adequate for distillation work, but can be further increased by lengthening the slot.

Although the present device was designed for reflux control, it is evidently applicable to many installations where it is desired to split a liquid stream into two parts of given, constant ratio. Its advantages include: No moving parts in operation; wide and continuous range of ratios, independent of throughput, pressure, viscosity, etc.; continuous, rather than intermittent, operation with relatively low holdup.

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1. Berg. L., *Ind. Eng. Chem.*, Anal. Ed., 18, 54 (1946).
2. Brunn, J. H., *Ibid.*, 7, 359 (1935).
3. Carter, A. S., and Johnson, F. W., U. S. Patent 2,251,185 (July 29, 1941).
4. Podbielniak Centrifugal Contractor Company, *Circ.* 22 (Nov. 1942). ★★★

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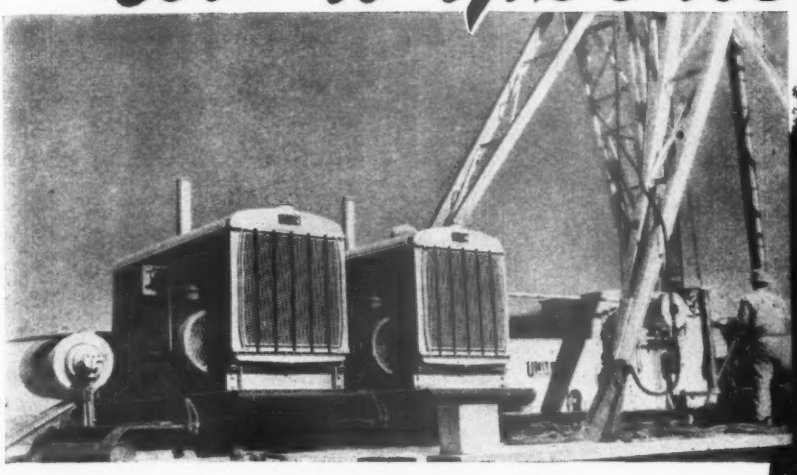

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Refinery safety

By DON ATTAWAY, Arkansas Fuel Oil Company

FROM its beginning more than 87 years ago, the petroleum industry has grown into a business that provides an annual income of more than two billions of dollars for almost one million people and represents an investment of hundreds of billions.

EXCLUSIVE

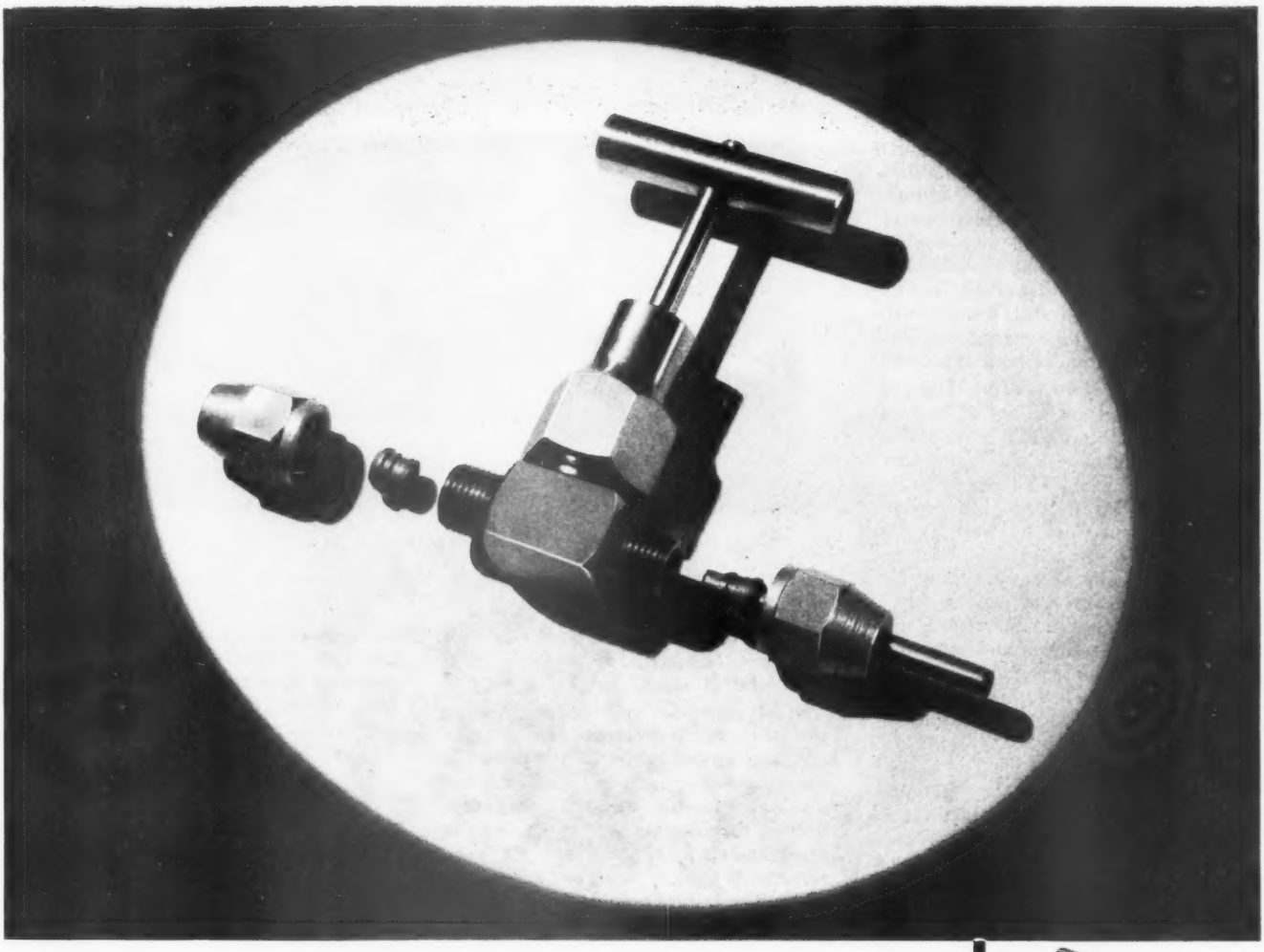
But the industry has not been without its tragedies. The early hazards were so many and complex that human lives were sacrificed in an endless stream to the conduct of the business. As recently as 1927, petroleum operations were claiming 18 per cent more lives than the average of all other industries. Fatalities occurred among the workers at the rate of 77 per 100,000 employes.

Early petroleum refineries were little more than crude tea-kettle stills with a capacity of a few barrels daily. The volatile vapors were unused in the early days and sources of ignition were everywhere. Little consideration was given to pressures and temperature.

This tremendous toll of human lives drew little or no attention until the American Petroleum Institute recognized accident prevention as a major problem within the industry. Accordingly, an appropriation was made to the National Safety Council for special work on the problem. In January, 1931, the Institute created its department of accident prevention and since that time the safety record of the petroleum indusry has been an outstanding example of accomplishment.

● **Petroleum's safety record.** In 1928, the industry recorded an accident frequency of 27.33 lost time accidents per million man-hours worked. In 1946, the frequency was 13.01 representing a decrease of more than 52 per cent—especially significant is the record of refining operations. In 1927, this one phase of the petroleum industry had an accident frequency of 31.15; but by 1946 the frequency had been lowered to 10.98 or reduced by more than 64 per cent.

It is estimated that refinery workers in the U. S. number more than 126,000 and work more than 283 million man-hours yearly. In spite of the outstanding safety gains made in the past, accident records for the last few years have shown an upturn in refinery mishaps and indications are present that a definite trend is forming. Some safety authorities feel that this is because workers go about their daily tasks with no feeling of anxiety, for they know that their chance of being killed on the job is remote indeed. Actual records show that twice as many accidental deaths occur off-the-job.



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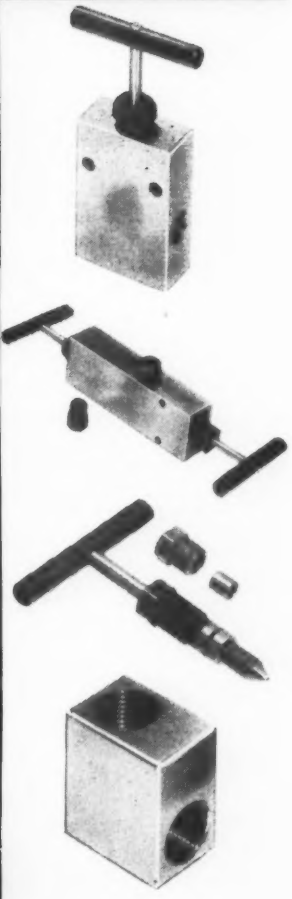

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● **New products and processes.** From the early days, refinery products have multiplied in an amazing manner. Petroleum is now the source of many fine motor fuels, lubricants, solvents, plastics, face creams, explosives, chemicals, and a thousand other essential commodities. Stills and vessels have grown into huge chambers of complicated design operating at almost unbelievable pressures and temperatures. All the fundamental dangers of handling an inflammable and explosive material are still present with countless new hazards ranging from dermititis to chemical radiation and poisons.

● **Refinery accident control.** The prevention of refinery accidents utilizes the same basic factors as any other industry. Top management in the form of executive attention must be drawn to the problem. For a safety program to succeed, the supervisors as well as the rank and file of the employes must understand and support the program.

A qualified safety engineer can best combine the interest of management and worker so that a common understanding of the program can be reached whereby safe procedures can be established, proper protective equipment used, and mistakes that damage equipment and injure workers can be eliminated. The proved formula for reducing accident is found in the safety engineer's three factors:

1. *Education*
2. *Engineering*
3. *Enforcement*

● **Education.** Training a worker for a job is as necessary for safe operation as the specification of the tested strength and make of equipment erected in the refinery. This job training can be carried on in a number of ways.

Some refineries conduct schools or classes for the various operating occupations. This is practical in large plants where considerable personnel is present and qualified instructors available.

Other refineries use worker conference meetings at certain time intervals where workers and foremen meet and discuss job procedures and physical conditions of the plant. This method is very successful in almost any refinery.

Every refinery worker should have full courses in first aid.

Small refineries can obtain the same results from safety trained foremen who can instruct and advise on the job while operation is in progress. Experience is a valuable teacher only when wisdom is present to guard against the pitfalls of error and lack of knowledge. A good foreman is the key to a good safety program. The failure or success of accident prevention usually rests in his hands.

To inaugurate such safety education in a refinery, a good start can be made from a review of past accident records. Two of the most common points of injury in a refinery is in operating equipment and handling material. This first point usually concerns skilled workers such as still men; while the second point is a problem of all workers.

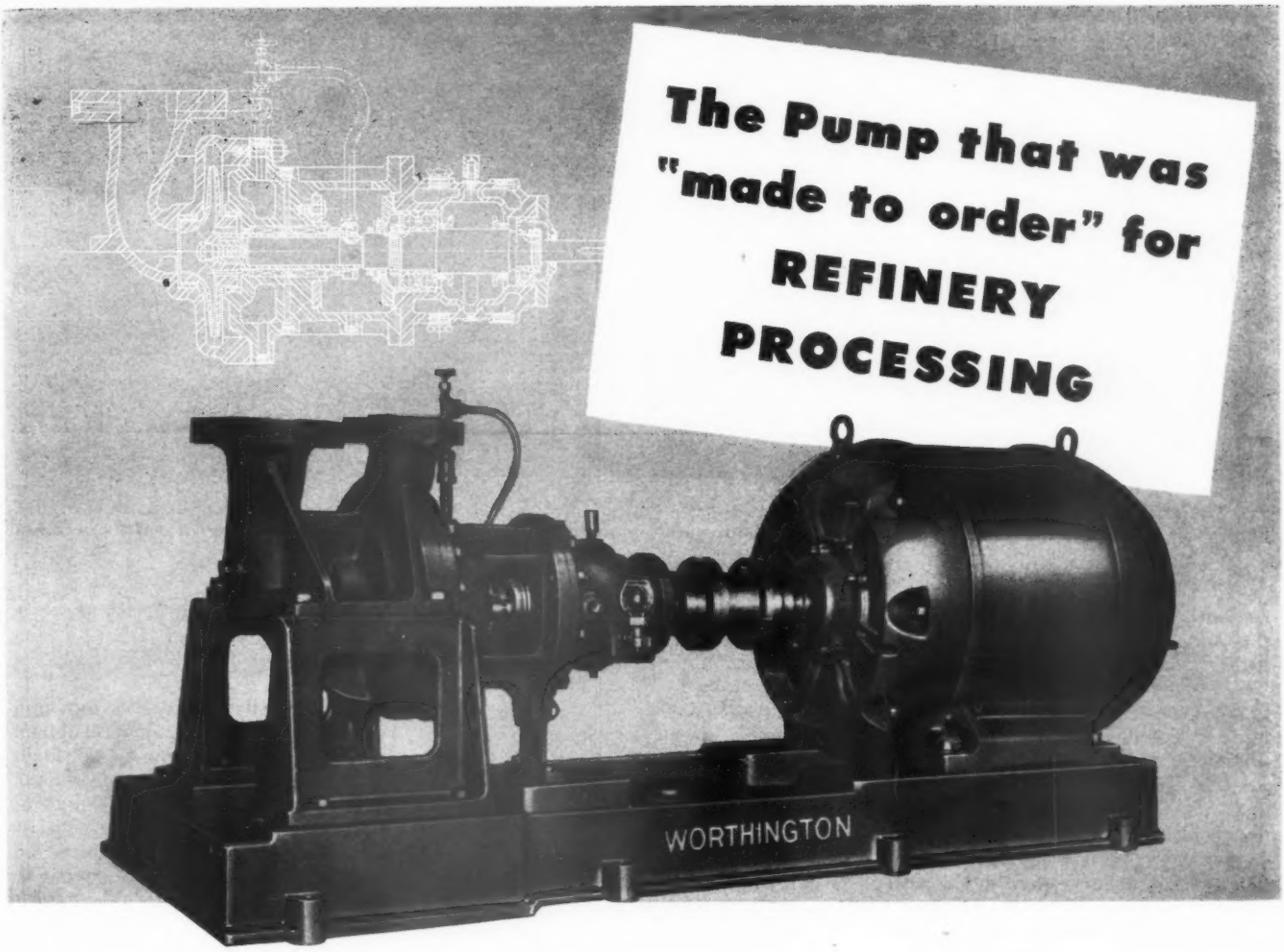
If the refinery size justifies a class, then arrangements should be made for a safety-education conference with the workers and a demonstration of the safe and correct operation of specific equipment where accidents have been occurring. If the refinery is small, then the foreman or supervisor should personally demonstrate and explain to the operating crew the "how" and "why" of safe and correct procedures.

The worker education must even extend into an investigation of all accidents. It is imperative that workers be shown the true cause of their accidents and carefully instructed in methods of preventing a recurrence. Such an investigation should be made with the foreman and parties to the accident or witnesses and should be directed to analyzing the accident for direct causes and correction rather than finding who was at fault.

Assistance in safety training of employes is available from numerous outside sources such as the National Safety Council, U. S. Bureau of Mines, U. S. Department of Labor, American Standards Association, American Petroleum

Handling hose lines and fognozzle operation is best shown by actual fire drill.

Operation of foam generators requires employe training to be able to judge best way to use them.



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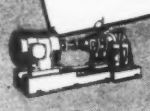

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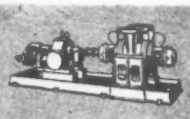

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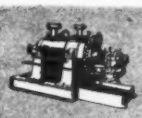
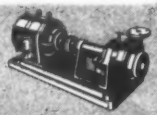


Type WH. High-pressure, high-temperature, centrifugal hot-charge pumps. Twelve distinct points of superiority, based on years of experience building pumps for high pressures and temperatures. Capacities to 2000 g.p.m., heads to 5000 ft.



Type HL. Several construction arrangements permit flexibility in application. Designed for temperatures up to 225°F., or higher with water-jacketed stuffing box. Capacities up to 1600 g.p.m., heads to 500 ft.

The "how" and "why" of fire extinguishers must be explained in detail. Actual demonstrations are important.

Training employes in fundamentals of fire-fighting is requirement of safe operation.

Institute, and countless others. Much of this aid is free and often includes the loan of sound slide strips and films for visual education. Other assistance comes in the form of safety posters, pamphlets, fire prevention, operating manuals, and first-aid training.

● **Engineering.** Job training and employe education alone will not solve the accident problem. While more than 75 per cent of all accidents involve a personal unsafe act, quite a few accidents result entirely or in combination with an unsafe mechanical or physical condition. Safety can be designed or constructed into a refinery if all plans and specifications are reviewed by a competent safety engineer before their final approval.

Many safety factors are to be considered in the layout of a modern refinery that do not necessarily fall into the knowledge or scope of a designing or construction engineer.

The topography of the plant site has a decided bearing on such things as drainage, fire protection, and climatic conditions. Locations of various units must meet certain requirements of codes and laws.

Safe access to any parts of equipment involves such things as correct stairs, ladders, treads, risers, railings, toeboards, and walkway surfaces. Improper hard rails, slippery walks, and faulty stairs have caused many bad refinery accidents.

Lighting type, location, and intensity have a very definite safety value in the refinery as it is a day and night continuous operation.

Health and sanitation have a very close connection with refinery safety and adequate wash and locker rooms are necessary.

The hazard of fire or explosion is perhaps the greatest in a refinery and a permanent electrical grounding system should be incorporated in all plants to eliminate ignition from static electricity. Fire protection can be constructed in a refinery very effectively. Tank farms and storage areas require proper location, firewalls, and piping, as well as adequate fire fighting equipment correctly situated and maintained.

● **Enforcement.** Experience and research have developed rules and regulations for safeguarding lives and equipment. These codes and regulations need enforcement to be effective. There can be no compromise or chance taking by substitution.

The simplest and surest method for obtaining enforcement of safe practices is to maintain regular and complete refinery inspections. No better device can be found for locating hazards and unsafe conditions. When the condition has been located, immediate and adequate correction must be enforced. Such correction is sometimes as simple as replacing a valve or erecting a guard rail. At other times the correction may be complicated and require the knowledge and ability of a safety engineer. Invariably a solution can be found without radical changes in construction, shut down, or alteration of the process.

Proper plant maintenance is good operation and it is also the essence of safety. Putting off or patching up repairs sometimes leads to serious accidents and usually extensive property damage. The findings of plant inspections should be promptly followed by corrective recommendations and these corrections enforced.

Certain refinery procedures and safe practices have been well established. These working arrangements constitute part of the workers education and they must be enforced. Rule books are of little value unless they set forth the how and why of operation methods and are followed.

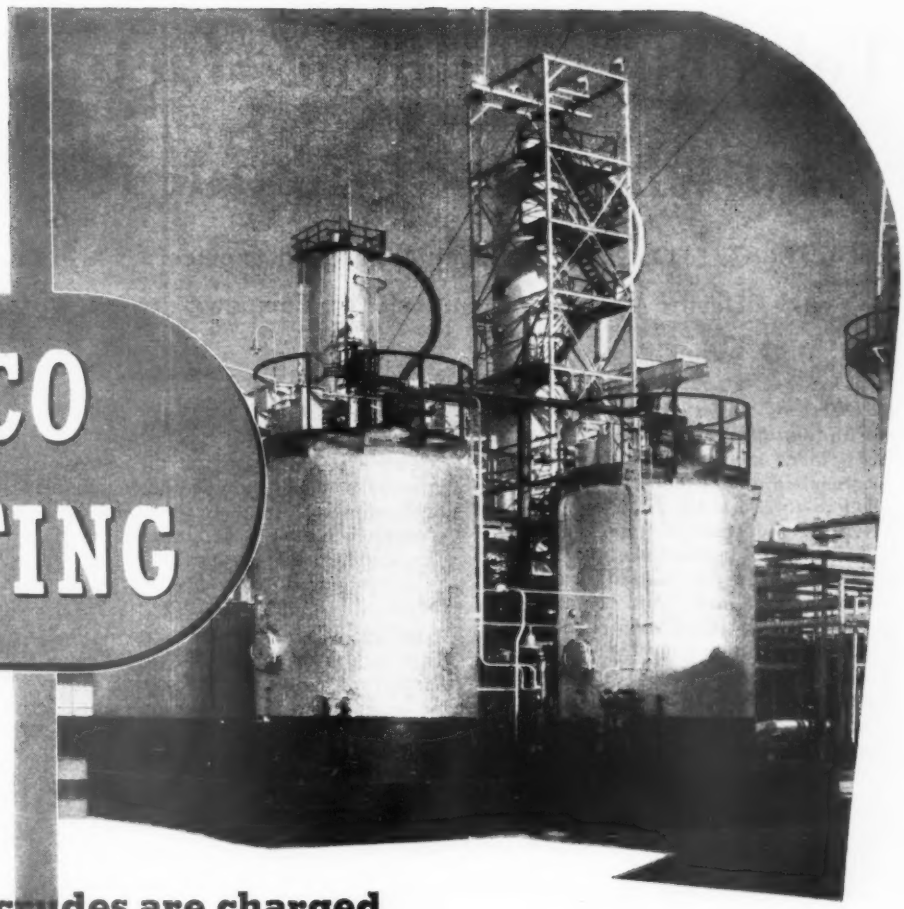
It might be well to point out that enforcement does not entirely refer to discharge of workers for rule violation. The capital punishment of industry has in the past been immediate discharge of employes for infraction of rules, but this theory has been found faulty and ofttimes workers commit errors because of incomplete instruction, lack of proper material and tools, and failure of management to provide adequate protective equipment.

Safety usually provides its own punishment for offenders in the form of damage or injury to those who take chances. Enforcement to a large degree consists of foremen and supervisors making prompt correction of unsafe conditions and in instructing workers who use unsafe or incorrect methods. Of course, repeated violations and utter disregard of rules calls for more drastic action.

● **General.** Safety in refinery operation, therefore, is a direct responsibility of management and no plant is any safer or more efficient than the owners and operators desire it. Quite often, the degree of safety to be found in a refinery can be found in the profit and loss column of the business.

Safety is an intangible asset with a variable value. Its true worth cannot always be found in the mechanical condition of the plant for many refineries have well-kept pumps, engines, and vessels as well as beautiful and neat plant sites, but give little or no attention to the physical condition or mental attitude of their workers. A great failing of management is to forget that men must be maintained as well as pumps. Employes need repairs, correction, and adjustment just as surely as engines. Safety is a great factor in good employe-management relations and the health and welfare of the worker plays a vital part in the quality and quantity of productive effort he puts forth.

Petroleum refineries can be safe places to work. Actual records show numerous plants working millions of manhours and year after year without a single disabling injury. An investigation of these records will show, however, that in each instance the refinery has a well planned and executed safety program. Intelligent management and trained workers sharing the knowledge and experience of the entire industry make this possible. ★★★



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Telephone influence factor and what to do about it*

By G. L. OSCARSON, *Chief Application Engineer,*
Electric Machinery Manufacturing Company

● **Effect of power system harmonics on communication systems.** An electrical engineer once stated that the energy consumed in an incandescent light was sufficient to cause all the telephone receivers in the state to hum. This was probably an exaggeration, but it illustrates forcefully the vast difference in energy level of power and communication circuits. We shall see a little later that an almost imperceptible wrinkle in a 60-cycle sine wave may cause excessive telephone noise.

Power circuits that parallel telephone lines, or are otherwise inductively coupled to them, may induce voltages, causing currents to flow, which will interfere with transmission and reception of sound energy. This may be described as telephone interference. The quantitative value of the interfering effect of some one power unit, taken individually, or of the power circuit as a whole has been evaluated and may be determined by circuits and meters developed for that purpose.

The first quantitative measure of power system interference on telephone lines was established by an AIEE subcommittee on wave standards in 1919[1]. The standard they proposed was known as Telephone Interference Factor and remained in effect until 1935.

In 1935[2] a new standard was adopted. This is known as Telephone Influence Factor, abbreviated to TIF, and has been the basis for all recent measurements. A further refinement was suggested in 1941 but has not been officially adopted. All material in this article is on the basis of the 1935 standards.

A telephone system must transmit a wide range of frequencies, the extreme probably being from 200 to 4000 cycles per second. If the higher frequencies are absent, speech would be intelligible but would be lacking in quality. Even if you knew the speaker well you would not recognize the voice. If the lower frequencies are absent the speech would be recognizable but not the words. It would sound like a foreign tongue.

Tests were made by reading news items to various listeners and also by articulation of unrelated syllables while currents of various frequencies, but equal amplitude, were superimposed on the circuit. The relative interfering effects determined from thousands of tests as plotted in curve form are shown in Fig. 1. This shows a peaking effect near 1100 cycles, which is approximately the resonant frequency of ordinary telephone receivers and is close to the point of maximum sensitivity of the human ear. It was found that the interference was proportional to the amount of current. It varied widely with the frequency as the curve shows.

It was desired to adjust the values in Fig. 1 so they would represent the effect of power system harmonics. It was found that the coupling effect on the telephone circuit varied as the frequency. A new series of values was thus obtained by multiplying the interfering effect (from Fig. 1) of each frequency, times the numerical value of the frequency itself. The resultant curve is shown in Fig. 2 and is the present Telephone Influence Factor. It is scaled on the basis that the TIF at 60 cycles equals 1. This curve is thus intended to include probable coupling effect at any given frequency as well as the interfering effect after the harmonic appears in the telephone circuit itself.

The voltage or current wave in each case is assumed to be a true sine wave. The table in Fig. 2 represents the TIF

*Presented at 19th Annual Conference Petroleum Industry Electrical Association, Houston, Texas, May, 1947.

1. H. S. Osborne, *AIEE Transactions*, 1919, p. 261-88.
2. J. M. Barstow, *AIEE Transactions*, 1935, p. 1307-15.

FIG. 1. Interference vs. frequency.

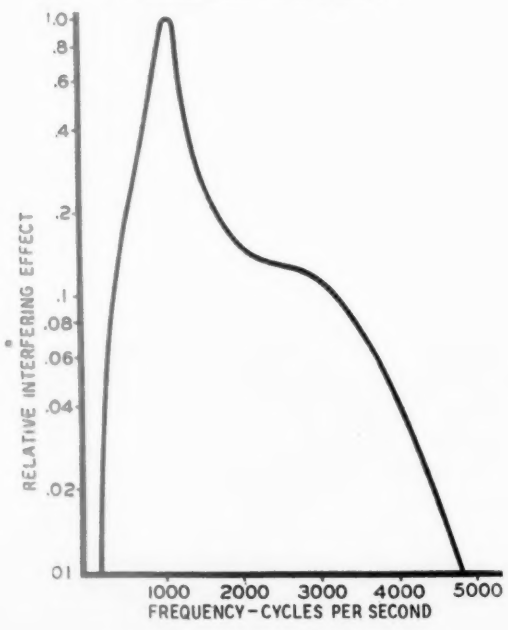
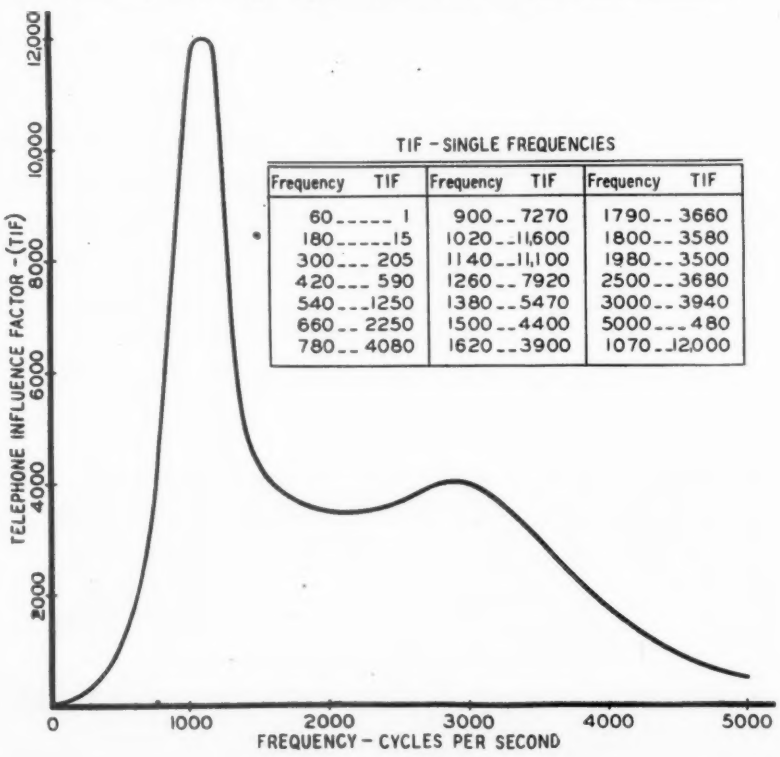


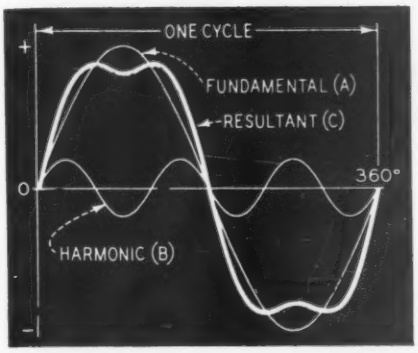
FIG. 2. Frequency weighting characteristics for TIF measurements.



TIF – SINGLE FREQUENCIES

Frequency	TIF	Frequency	TIF	Frequency	TIF
60	1	900	7270	1790	3660
180	15	1020	11,600	1800	3580
300	205	1140	11,100	1980	3500
420	590	1260	7920	2500	3680
540	1250	1380	5470	3000	3940
660	2250	1500	4400	5000	480
780	4080	1620	3900	1070	12,000

FIG. 3. Fundamental and third harmonic.



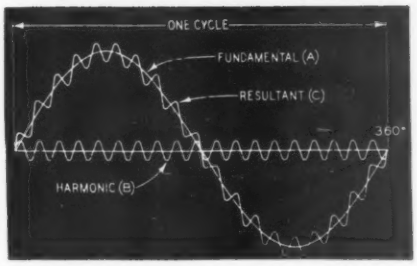


FIG. 4. Fundamental and nineteenth harmonic.

values for various frequencies. Any fundamental 60-cycle wave which is not a true sine wave with a TIF of 1 may be resolved into a 60-cycle sine wave with one or more harmonics (such as a 3rd, a 5th, or higher value) superimposed on it.

Fig. 3 illustrates a 60-cycle sine wave with a 3rd harmonic having an amplitude of 20 per cent of the fundamental. It can be shown that the TIF for such a wave would be approximately 3.15.

Fig. 4 illustrates a 60-cycle fundamental with a 19th harmonic having an amplitude of 10 per cent. Due to this frequency being close to the peak of the TIF curve the resultant (harmonic superimposed on the fundamental) would have a TIF of 1110.

It is obvious that the harmonics on the power system will probably be present both in the voltage wave and the current wave. For convenience, measurement is usually made at the generator terminals of open circuit no-load voltage TIF. The effect of adding load to the generator is usually to reduce the open circuit TIF. Adding capacitors to a system for power factor correction accentuates the higher harmonics, however, and usually increases the TIF at the generator terminals.

Obviously, as far as magnetic induction is concerned, the product of current times TIF is a measure of the interfering effect. A generator with an operating current of 200 amp and a TIF of 20 will cause twice as much interference in a given location as a unit carrying 100 amp and having a TIF of 20.

The source of telephone interference is not limited to generators. It may arise in synchronous or induction motors and may be accentuated by capacitors.

One of the worst cases of telephone interference encountered by one investigator for the telephone company was caused by a low speed, slip ring induction motor coupled to a flour mill lineshaft. The actual interfering effect of any one machine is in proportion to the current it supplies to (or draws from) the line. In general the TIF on any circuit will be better than that of the worst unit connected to it.

Summarizing we might say that the TIF of any unit is proportional to its interfering effect on a telephone system compared to the relative interfering effect of a 60-cycle pure sine wave of the same effective value.

Communication systems used with pipe-line systems probably universally have ground return. In such cases transposition of any paralleling power lines should be quite complete. Grounded star-connected transformer banks or generators can be quite productive of interference unless the residual TIF is held very low.

It is not likely that motors in pumping stations will be the cause of appreciable interference unless they are operated with grounded neutral. A current coupler and a TIF meter can be used to check possible interference values.

If capacitors are used to correct the power factor of pipe-line induction motors they may easily be productive of interference.

A rough check on motor or capacitor interference can readily be obtained by switching units on and off and determining the distance the hum can be heard from the telephone receiver.

● **Measuring TIF.** The circuit for one type of TIF meter is illustrated in Fig. 5. The circuit constants are so selected that the admittance to flow of current at various frequences follows Fig. 2 above. The meter is a thermocouple type d-c milliameter. Usually the terminals at E are connected through a potential transformer as shown to the circuit under test. Readings are taken in volts and microamperes. Quantitatively,

$$\text{TIF} = \frac{\text{micro-amps}}{\text{volts}}$$

This arrangement is used to measure voltage TIF either at no-load or under load. To read current TIF a current coupler is used.

Many noise meters are now provided with resonant networks designed for TIF reading and may be used to measure voltage or current TIF. An analyzer can be attached to the noise meter circuit, permitting readings of the amplitude of all harmonics present.

The important TIFs on synchronous machines or motors are the balanced TIF and the residual TIF.

On the ungrounded-star or on a delta connected generator, the open circuit, no load TIF, measured terminal to terminal is the balanced TIF. The possible components are the non-triple odd harmonics such as the 5th, 7th, 11th, etc. Within the machine itself triple harmonics such as 3rd, 9th, 15th, etc., may circulate in a delta connection but do not appear external to the machine. The algebraic sum of the 3-phase voltages and currents at any instant is zero with respect to earth. The TIF resulting from the non-triple harmonics that appear is known as the balanced TIF.

Present NEMA standards on balanced TIF are as follows:

Kva	TIF
62.5–299	300
300–699	200
700–999	150
1000–2499	125
2500–9999	60

If a machine is operated grounded neutral, however, the triple harmonics 3rd, 9th, 15th, etc., will appear at the load and return via the ground lead. As the triple harmonics in all three phases are themselves in phase they are not balanced out and a residual component will flow. Star connected transformer banks may also set up residual currents due to

FIG. 5. Circuit for one type of TIF meter.

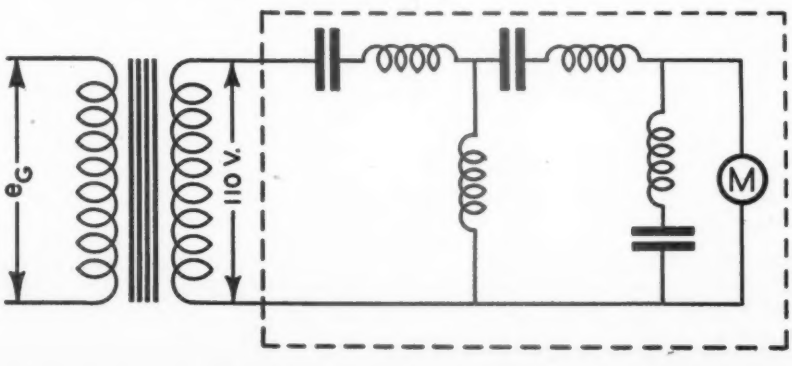
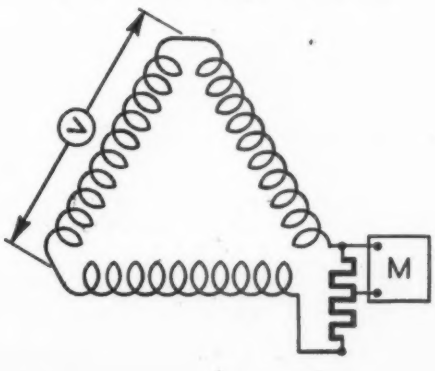


FIG. 6. Measuring residual TIF.



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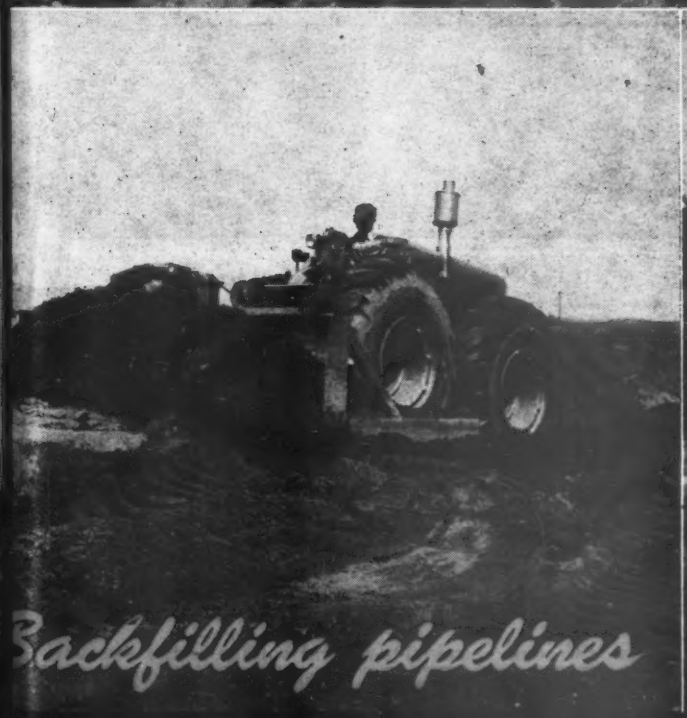

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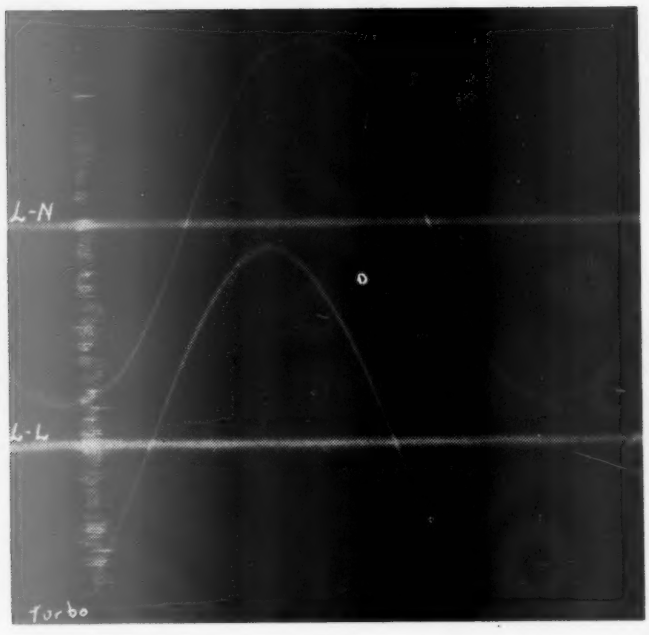


FIG. 7.

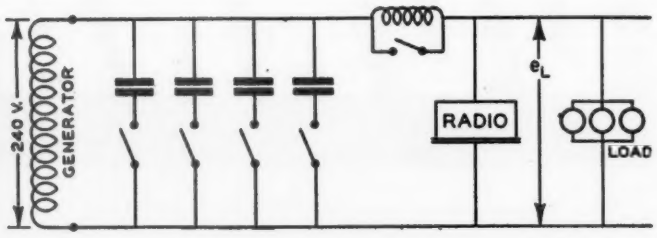
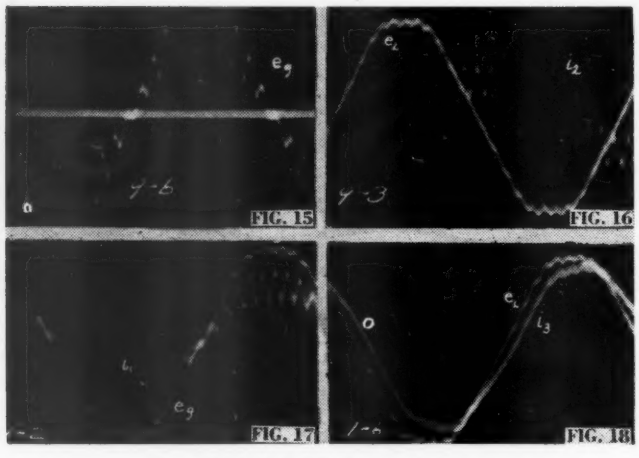


FIG. 14. Filter circuit No. 1.



FIGS. 15, 16, 17, and 18.

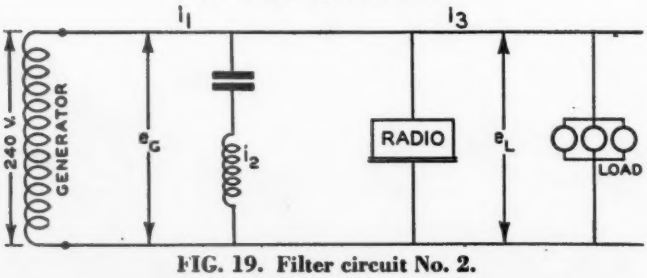
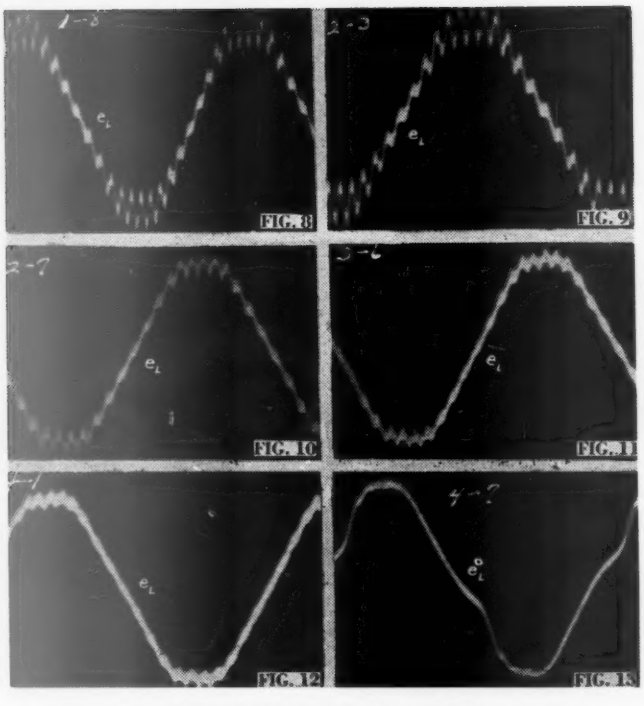


FIG. 19. Filter circuit No. 2.



FIGS. 8, 9, 10, 11, 12, and 13.

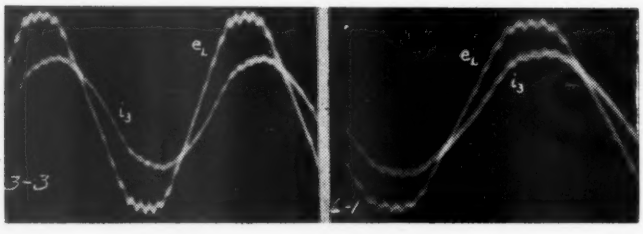


FIG. 20. FIG. 21.

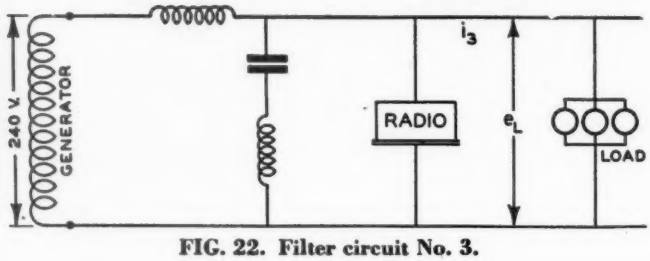


FIG. 22. Filter circuit No. 3.

variation in iron permeability. An extreme example of residual current with respect to earth would be a single phase traction system with overhead trolley and ground return. Such a system is 100 per cent unbalanced and all currents and voltages are residual.

To measure the residual TIF of a machine, it is connected delta with one corner open as per Fig. 6. The TIF meter is connected across the open terminals through a voltage coupler and full terminal-to-neutral voltage is generated and measured by voltmeter V. One third of the current in microamperes as measured by the TIF meter divided by terminal-to-neutral voltage is the residual TIF. The voltage across the open terminals may vary from about 0 to 10 per cent of the voltage "V." This voltage is proportional to the magnitude of the triple harmonics circulating in the delta. On a machine wound 2/3 pitch the residual TIF could theoretically be zero.

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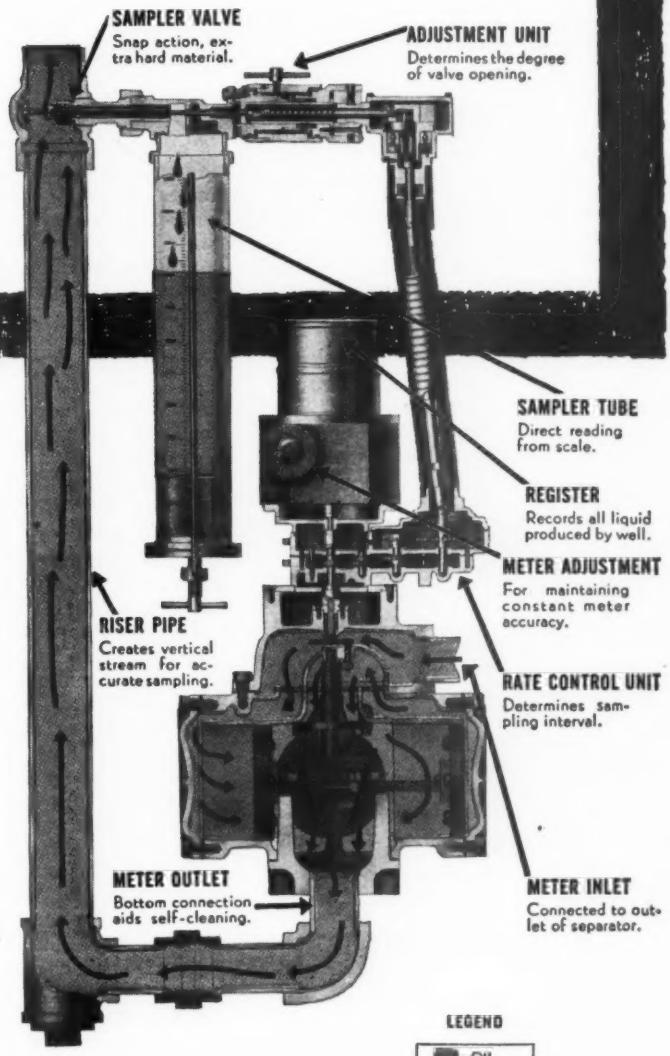

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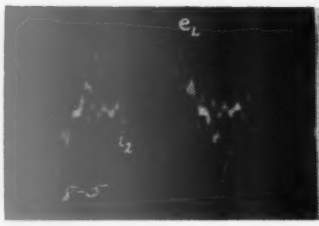


FIG. 23.

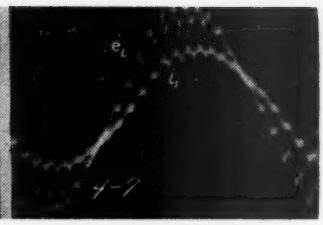


FIG. 24.

FIG. 26

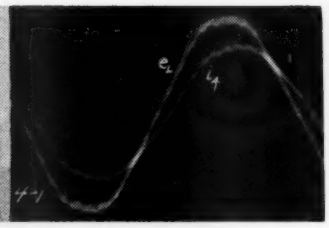


FIG. 27.

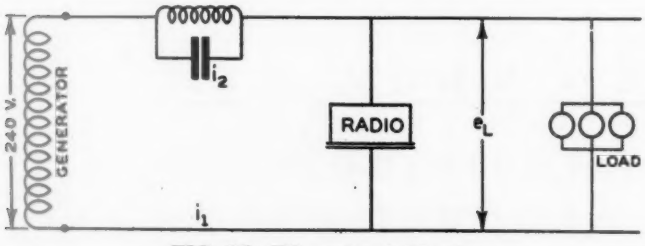


FIG. 25. Filter circuit No. 4.

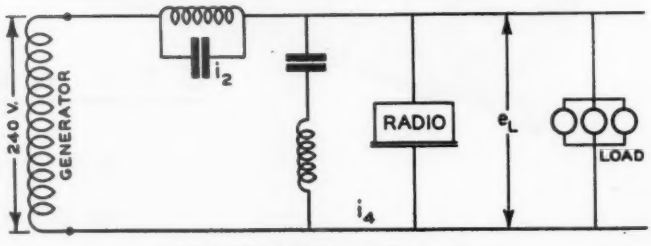


FIG. 28. Filter circuit No. 5.

NEMA standards on residual TIF are:

Kva	TIF
62.5–299	180
300–699	120
700–999	90
1000–2499	75
2500–9999	30

Actually communications engineers are quite consistently insisting on residual TIFs of not more than 2.5 on generators to be operated grounded neutral.

● **Machine characteristics affecting TIF.** The harmonics that are superimposed on the 60-cycle fundamental are caused primarily by stator slots. On two-pole generators the rotor slotting will also be an important factor. Salient pole machines with amortisseur windings may be productive of high TIF values depending on damper bar spacing. Pole shape, coil pitch, saturation, and air gap are all important contributing factors to TIF.

Fig. 7 shows voltage to neutral L-N, and terminal to terminal L-L voltage waves on a 3000-kw, 2-pole turbine generator. Off-hand the line-to-line trace looks like a very good sine wave but a faint ripple is perceptible at the peak of the wave. This turns out to be slight 17th, 19th, and 23rd harmonics and the resultant balanced TIF is 19.9, which is not acceptable for some installations. The rotor slot spacing on this machine is equivalent to 28 slots and the stator spacing provides 42 slots.

On this machine the following values of balanced TIF were obtained at the coil spans indicated:

Coil pitch	Balanced TIF
52.6 per cent	24
57.2 per cent	15.6
66.7 per cent	19.9

☆ ☆ ☆

An American-made oil refinery with a capacity of about 14,000 bbl per day, or 470,000 tons monthly, has been purchased by a Swedish concern to be erected in Gothenberg by 1948.

Residual TIFs on two coil pitches were obtained and were as follows:

Coil pitch	Residual TIF
57.2 per cent	19.7
66.7 per cent	3.4

On small machines stator coil slotting is usually selected that will not result in harmonics close to 1100 cycles. Skewing of the stator core is universally resorted to in minimizing harmonics that cannot be avoided. Engine type low speed machines will usually have the pole pieces skewed when low TIF values are desired.

On two-pole turbine generators the large air gap helps smooth out flux irregularities and keeps the TIF value low. Undesirable combinations of rotor and stator slotting are avoided.

In practically all cases if a very low value of residual TIF is desired it may be necessary to resort to ⅔ coil pitch, which is generally somewhat expensive.

● **How TIF may be reduced.** The following studies all deal with a 40-kva, 1200-rpm, 120/240-volt, 3-wire, single-phase generator. It had a pronounced 23rd harmonic, having an amplitude of about 15 per cent of the fundamental and an open circuit TIF of about 750. Fig. 8 represents the voltage wave with a unity PF load of 56 amp, approximately one-half of full load.

In attempting to reduce the harmonic content various types of filters were applied. The first type of filter applied (Filter No. 1) is shown in Fig. 14. It consists of 4-120 MFD condensers and an iron core reactor that could be switched on in succession.

No TIF meter was available to make quantitative readings; however, a small, poorly filtered radio was plugged into a 120-volt circuit. The radio volume control was held at a fixed point and the radio was detuned from any local station. The only sound from the radio speaker was that due to hum originating in the power supply. The audible hum was nearly proportional to the amplitude of the harmonic and this together with visual inspection of the oscillograms was the only quantitative information obtained. The different filter combinations for filter 1 and the results are tabulated below:

Fig.	Filter	Load	Comments
8	None	56	Hum audible at 6 ft.
9	120 MFD	56	Hum audible at 6 ft.
10	240 MFD	56	Objectionable hum 0.5 ft.
11	360 MFD	56	Noticeable hum 0.5 ft.
12	480 MFD	56	Faint hum 0.5 ft.
13	480 MFD iron core.	56	Faint hum 0.5 ft.

This is a "brute strength" type of filter, fairly effective over a wide range of frequencies, but if the power factor is already high it actually adds to the fundamental current on the generator. The iron core reactor introduces a pronounced 3rd harmonic in Fig. 13. It is not a desirable type of filter.

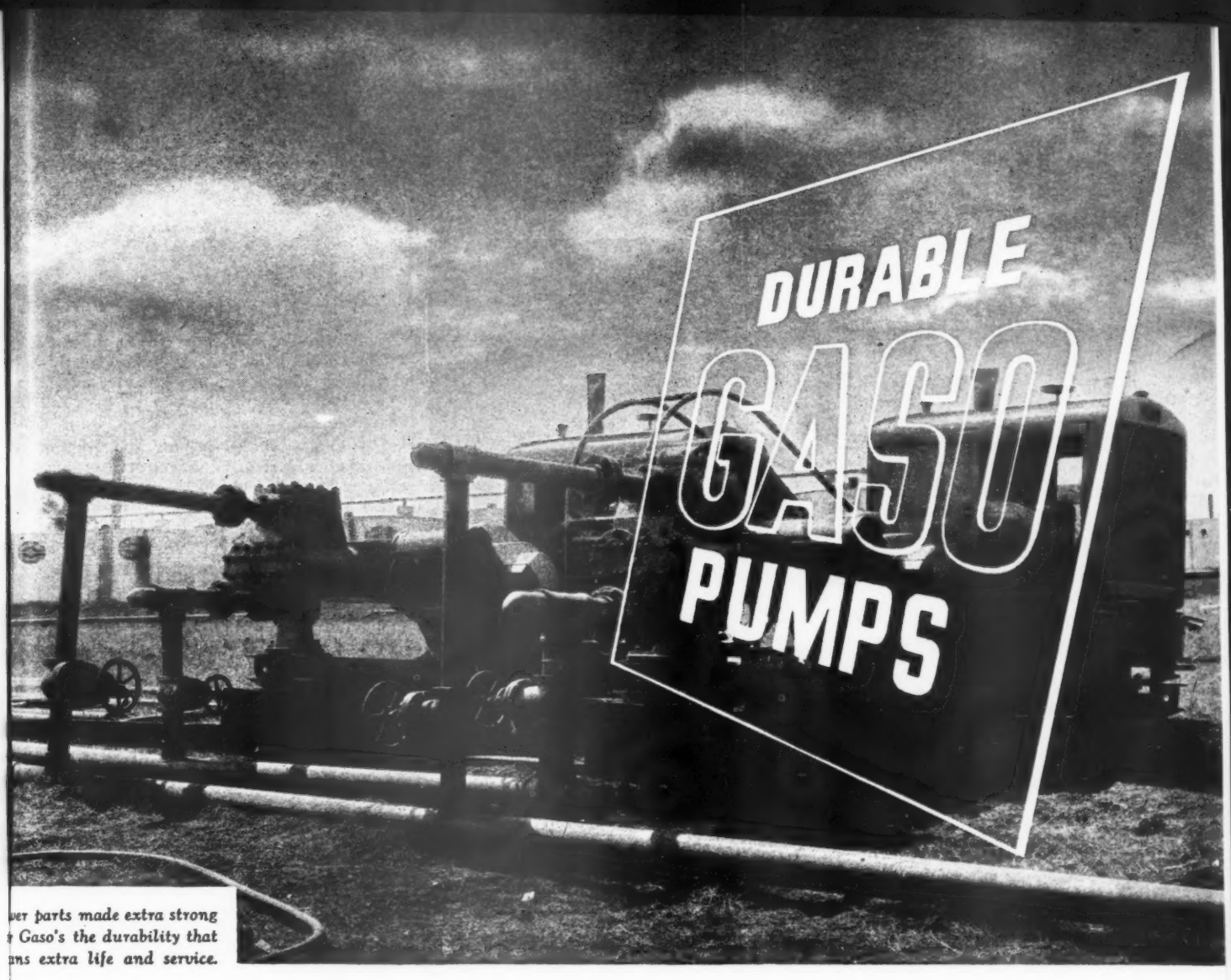
To avoid the excessive armature current caused by a filter No. 1, a series resonant filter as shown in Fig. 19 was applied.

The wave shape and hum was quite comparable to Fig. 12 using filter type 1; however, the increase in fundamental current due to the filter was only about 25 per cent as much as was caused by that circuit. The data for the various oscillograms are as follows:

Fig.	Filter	Load	Comments
15	None	0	Hum audible at 6 ft.
16	Fig. 19	0	Hum not appreciable at 0.5 ft.
17	Fig. 19	56	Hum just audible at 0.5 ft.
18	Fig. 19	56	Hum just audible at 0.5 ft.

Series reactance was added to the filter in Fig. 19. The reactor was of the air core type and had twice the reactance for Fig. 21 that it had for Fig. 20. In each case the hum was just audible as it was in Fig. 19. As no improvement was noted and as an extra loss existed in the series reactor, this type of filter was not used.

A tuned unit as shown in Fig. 25, consisting of a capacitor in parallel with a



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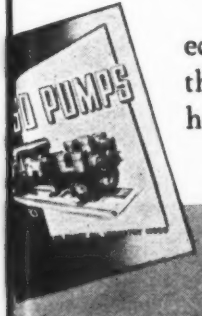

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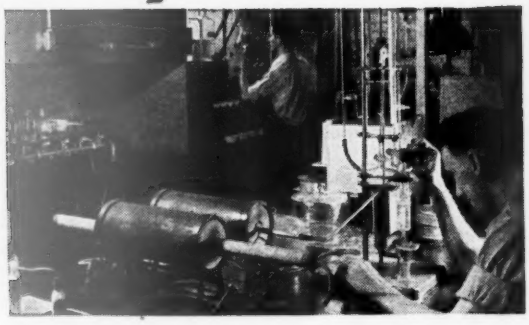

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reactor, was connected in series with the load to determine its effect. The results are shown in Figs. 23 and 24. Observed conditions were as follows:

Fig.	Load	Comments
23	0	Audible hum at 6 ft.
24	36	Appreciable hum at 6 ft.

With a filter of this type the harmonic voltage divides across the filter and across the load in proportion to their respective impedances. At light load this type of filter is not very effective as the impendance across the load itself is quite high.

If the load impedance for the harmonic is made sufficiently low, the series tuned filter (Fig. 25) would be effective under all load conditions. This can be accomplished by providing a filter as shown in Fig. 28, which adds a tuned shunt filter to the series filter in Fig. 25. This tuned shunt filter provides an effective short circuit for the harmonics. The load impedance for the harmonics is thus very low and most of the harmonic voltage appears across the series filter. The observed conditions on this filter were as follows:

Fig.	Load	Comments
26	0	No observable hum at 0.5 ft.
27	46	No observable hum at 0.5 ft.

From the foregoing we may draw the following conclusions:

1. The actual amplitude of harmonic required to cause considerable telephone interference may be quite low. For instance, a 1 per cent harmonic at 1020 cycles (17th harmonic) will cause a TIF of 116.

2. TIF alone is not the entire criterion of the amount of interference that can be expected. Whether telephone line is metallic or grounded, and whether power system operates 3-phase grounded neutral will have important results. Inductive exposure, such as long parallel lines, and effectiveness of line transposition are also important.

3. Motors or generators may be equally important in producing telephone interference. The effect of any unit is proportional to its TIF and to its proportional current compared on that part of the system influencing the telephone lines.

4. Harmonic content may be quite effectively controlled in the design of rotating electrical equipment.

5. Harmonics may be effectively removed by providing a "short-circuiting" low impendance path from terminal to terminal, for the higher harmonics.

6. A tuned filter is most effective in removing harmonics without impairing generator performance.

7. A tuned filter is quite selective as to the frequencies it will eliminate.

8. The most effective filter has a series tuned unit and a parallel tuned filter. Such a filter is quite selective also.

9. Where various interfering harmonics are present a "brute strength" type filter, as shown in Fig. 14, might be necessary. ★★★

Multi-column distillation of natural gasoline*

By FRANK J. LOCKHART, Chemical Engineering Department,
University of Southern California

THE separation of natural gasoline into its various components by distillation has received much attention with respect to the design of individual columns, but little attention has been given to the possible sequences of distillation columns that may be used to produce three or more products. This paper presents economic comparisons of a number of possible process arrangements of distillation sections in present day natural gasoline plants. Emphasis is placed upon the sequences of deethanizing, depropanizing, deisobutanizing, and debutanizing of natural gasoline.

● **Product quality.** Calculations were made in all cases for the following product specifications: (1) Natural gasoline with 12 lb RVP, containing approximately 1 per cent butanes; (2) n-butane, containing 5 per cent isobutane and 3 per cent pentanes; (3) isobutane, containing 5 per cent n-butane and 3 per cent propane; (4) comercial propane, containing about 2 per cent ethane and 2 per cent butanes; (5) ethane and lighter, containing sufficient propane to obtain condensation for reflux at 450 psig and 100 F.

*Presented before California Natural Gasoline Association, Los Angeles.

● **Estimating procedure.** As this paper is concerned only with the comparison of different sequences of columns to obtain the same products, incremental costs are used instead of total costs. Equipment such as vapor lines, reflux lines, reflux drums, valves, instruments, and pumps that are common to all sequences are eliminated from consideration.

● **Sizing of distillation columns.** Process engineers generally use shortcut approximate methods of design for economic comparisons. The design procedure given here has been used for a number of years with satisfactory results. This procedure is recommended only for preliminary estimations, although some distillation columns have been designed on this basis (and operated successfully). The final process design should be made by more accurate methods.

The procedure recommended for estimating purposes includes the calculation of the minimum number of theoretical liquid-vapor contacts and the minimum reflux ratio, which represent the limiting or boundary conditions of actual operation. The minimum number of theoretical liquid-vapor contacts is calculated from the Underwood[10] or Fenske[5] equation:

$$N^*_m \log L = \log\left(\frac{x_{LKD}}{x_{hKD}} \times \frac{x_{hKW}}{x_{LKW}}\right) \quad \ldots\ldots\ldots\ldots (1)$$

Where:

N^*_m = minimum number of theoretical liquid-vapor contacts (includes reboiler and partial condenser if present),

L = average relative volatility of the light key component referred to the heavy key component,

x_{LKD}, x_{LKW} = mol fractions of the light key component in the overhead product and bottoms product, respectively,

x_{hKD}, x_{hKW} = mol fractions of the heavy key component in the overhead and bottom products, respectively.

The minimum reflux ratio required for the separation cannot be determined accurately for multicomponent mixtures by any short, simple method. The Underwood equation[10] is accurate for binary mixtures, but is conservative for multicomponent mixtures. Equation (2) applies when the feed is at its bubble point, being identical with the corresponding Underwood equation for binary mixtures.

$$R^*_m = \frac{(x_{LKF} + x^*_{KF})}{L - 1} \frac{x^*_{LKD}}{x_{LKF}} \left(-\frac{L x_{hKD}}{x_{hKF}}\right) \quad \ldots\ldots (2)$$

Where:

R^*_m = approximate reflux

FIG. 1. Accuracy of minimum reflux calculation recommended for estimating purposes.

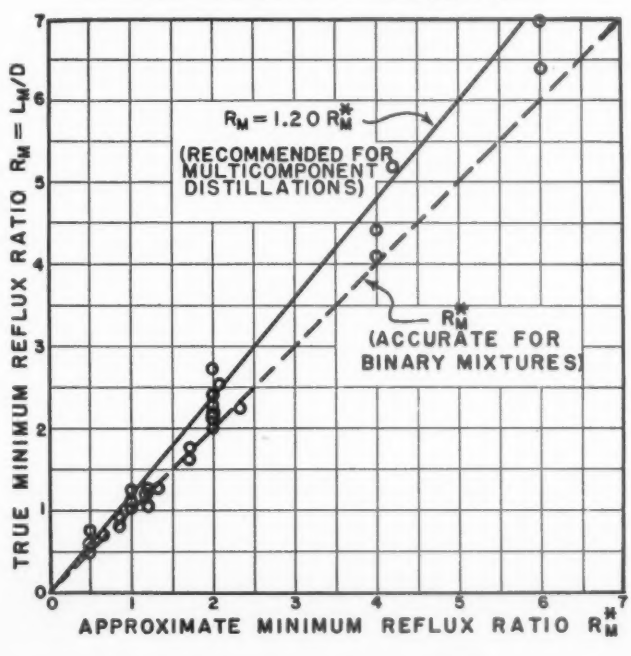
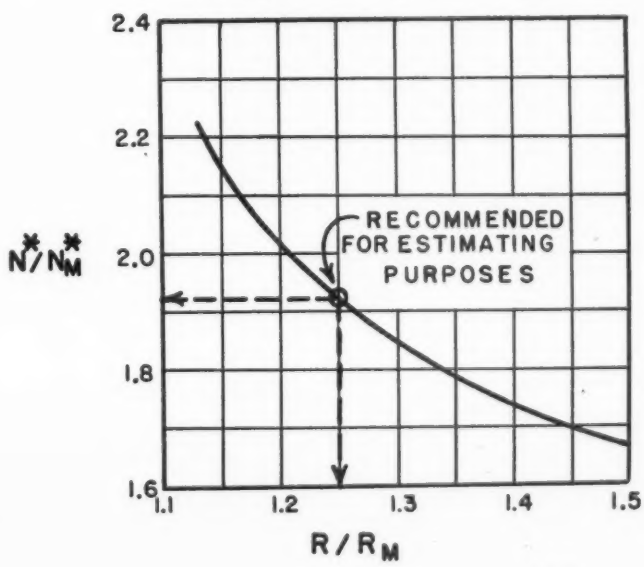


FIG. 2. Relationship between actual reflux ratio and number of theoretical liquid-vapor equilibrium contacts.



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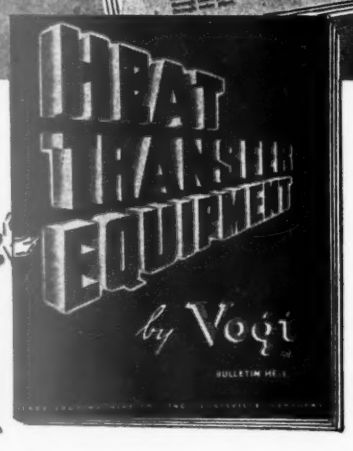

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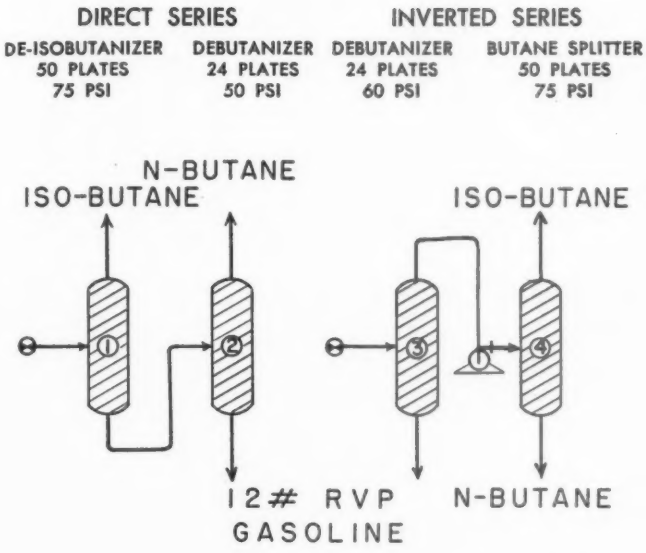

FIG. 3. Sequences of de-isobutanizing and debutanizing natural gasoline.

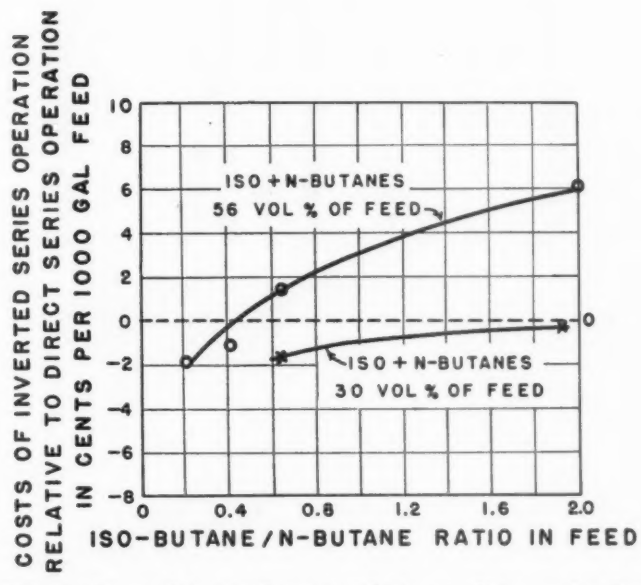

FIG. 4. Costs of inverted series relative to direct series for production of iso-butane, n-butane, and 12-lb RVP gasoline.

ratio calculated by equation (2) equals Lm^*/D.

x_{LKF}, x_{hKF} = mol fractions of light key and heavy key components, respectivly, in the feed to the column.

All other symbols as defined in equation (1).

The approximate minimum reflux ratio calculated from equation (2) is compared with the true minimum reflux ratio in Fig. 1, the points shown being for multicomponent distillations reported in the literature[2,3,6]. It is recommended that for estimating purposes, the value of the minimum reflux ratio be taken as 1.2 times the value of R^*_m calculated by equation (2) for multicomponent distillations. It should be emphasized that this procedure gives a value of minimum reflux ratio accurate to about 15 per cent only when the feed to the column is at or near its bubble point.

The relationship between the actual reflux ratio and the number of theoretical liquid-vapor contacts required for the separation is given in Fig. 2. This relationship is a simplified form of the Brown and Martin[2] and the Gilliland[7] correlations, and is accurate for most cases encountered in industry (the feed at or near its bubble point, the minimum reflux ratio between 0.5 and 15, and the minimum number of theoretical liquid-vapor contacts between 6 and 50). It is recommended that for design purposes the actual reflux ratio be taken as 1.25 times the minimum reflux ratio, because this point corresponds with the economically optimum operation of most hydrocarbon distillation columns.

Overall plate efficiencies, used to convert the number of theoretical liquid-vapor contacts to the number of actual bubble cap plates, may be obtained conveniently from the correlation of Drickamer and Bradford[4] or that of O'Connell[8].

Plate spacings of 25 in. were used in all calculations in this paper. Column diameters were estimated by the correlation of Souders and Brown[9] as modified by Brown and Lockhart[1], and rounded to the next larger half-foot.

Design pressures were considered as 50 psi higher than operating pressure. Deethanizers were limited to 450 psig operating pressure in all cases.

● **Sizing of extraneous equipment.** Heat exchanger loads were determined by conventional heat balances. All product and reflux streams were cooled to 100 F, while cooling water in all cases had an allowable temperature rise of 30 F. The reboilers for columns used 150 psi steam, with the control valves in the steam line 70 per cent opened in all cases, except those specifically mentioned later.

The only pumps considered in this study were those required to transfer feeds to columns from lower-pressure accumulators.

● **Cost analyses.** Fixed charges (depreciation, maintenance, etc.) were taken as 20 per cent per year of the initial investment costs, which include the costs of columns, heat exchangers, and pumps on an incremental basis. The cost of columns, erected in the Los Angeles area and complete with insulation, ladders, and platforms, was taken as 20 cents per lb total weight, a figure in agreement with turnkey estimates made in 1946. The costs of heat exchangers varied from \$4 to \$8 per sq ft transfer area, installed basis, in accordance with 1946 quotations. The cost of pumps and drivers were also in accordance with 1946 estimates, installed with connecting piping.

Operating charges were based on the following unit cost figures:

150 psi steam	20 cents per M lb
Cooling water	0.5 cent per M gal
Power	0.5 cent per kwhr
Fuel	15 cents per MM Btu

● **Scope of the calculations.** Production of the five streams specified previously requires four distillation columns in most instances. It is possible to arrange these four columns in at least 14 different sequences. An attempt has been made to simplify the comparisons of different sequences by considering a number of separations requiring two columns for three products. Specifically, the following cases were investigated: (a) Separation of depropanized gasoline into isobutane, n-butane, and 12-lb. RVP gasoline; (b) separation of deethanized gasoline into propane, isobutane, and deisobutanized gasoline; (c) separation of raw natural gasoline into ethane and lighter, propane, and depropanized gasoline. Results of the study are presented in that order.

● **Deisobutanizing and debutanizing gasoline.** After propane and lighter constitutents have been removed, two distillation columns are required to produce isobutane, n-butane, and 12-lb RVP gasoline. The columns may be placed in either the so-called "direct" series or the "inverted" series as indicated in Fig. 3. These two sequences have been compared for the feed compositions and rates indicated in Table 1.

The feed rates listed in Table 1 were

TABLE 1. Feed stocks corresponding with Figs. 3 and 4.

	Feed A	Feed B
Rate, gal per hr	2200.0	4100.0
Composition, vol per cent:		
Propane	0.4	0.2
Isobutane	56.5	30.3
n-Butane		
Isopentane	16.9	27.2
n-Pentane	8.8	14.2
Heavier	17.4	28.1
	100.0	100.0

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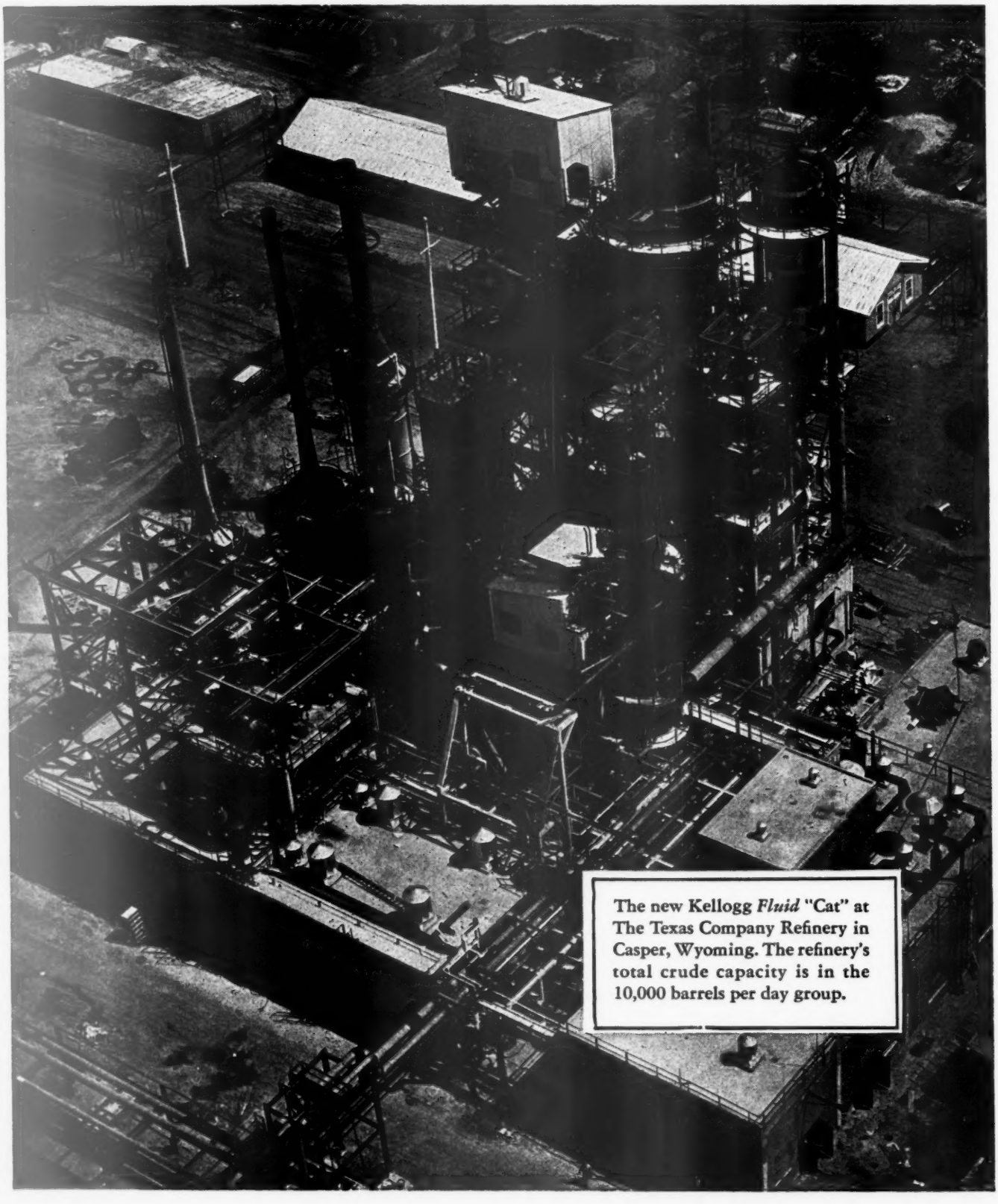

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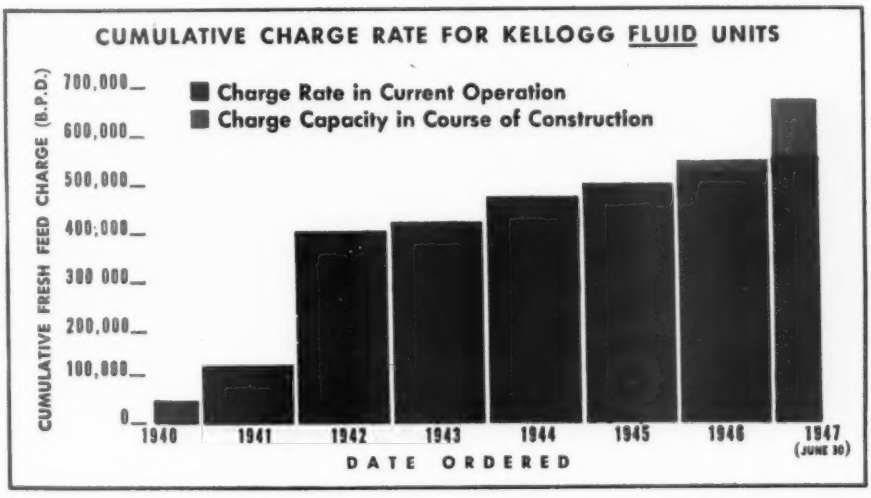

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selected so that all column diameters would be at least 2 ft. Feed B is a heavier stock than Feed A; it also represents the total feed where Feed A is the net feed and two volumes of gasoline are recycled to the still per volume of net gasoline product.

Results of this study are shown in Fig. 4. It is to be noted that the costs given in Fig. 4 represent the differences between the costs of operation of the inverted series and the direct series for the same feed and products. The ratio of isobutane to n-butane in the feed is ordinarily between 0.2 and 0.7 for natural gasoline stocks but the curves were extended to a ratio of 2/1 to include many refinery operations.

The inverted series compared with the direct series has in general higher fixed charges, principally due to the feed pumps required for the second column, and a lower operating cost, principally due to the reduction in steam consumption. It is interesting to note that the reflux rates are about 10 per cent lower for the inverted series operations.

The following conclusions may be applied to new plants and also to existing plants in which the addition of a new column is planned to separate mixed butane into isobutane and n-butane:

(1). If the isobutane concentration in the depropanized gasoline is relatively high, say more than 30 vol. per cent, as in some refinery operations, the direct series is preferred.

(2). If the isobutane concentration in the depropanized gasoline is relatively low, say less than 15 vol. per cent, the inverted series is preferred.

(3). If the gasoline concentration in the depropanized gasoline is relatively high, say more than 70 vol. per cent, the inverted series is preferred.

(4). For cases not covered by the first three conclusions, either series may be used without undue loss. The optimum sequence must be determined for each individual problem, and will depend upon such factors as the specific feed rate, the sizing of equipment, and the unit cost figures.

TABLE 2. Feed stocks corresponding with Figs. 5 and 6.

	Feed C	Feed D
Rate, gal per hr.	2570.0	4500.0
Composition, vol per cent:		
Ethane	0.4	0.2
Propane	36.3	21.5
Isobutane		
n-Butane	28.0	16 9
Isopentane	13.8	23.3
n-Pentane	7.2	12.8
Heavier	14.3	25.3
	100.0	100.0

TABLE 3. Ethane/propane ratio in feed greater than 0.6.

	Direct series	Inverted series
Operating pressure, psi	(1) 450, (2) 215	(1) 450, (2) 450
Compressors	none	one
Heat supply required for reboilers	(1) 150 psi steam (2) 150 psi steam	(1) 400 psi steam or fired reboiler (2) 150 psi steam

● **Depropanizing and deisobutanizing operations.** The separation of the deethanized feed into propane, isobutane, and deisobutanized gasoline may be accomplished by either a direct series or inverted series as shown in Fig. 5. These two sequences have been compared for the feed compositions and rates given in Table 2.

The feed rates listed in Table 2 were selected so that all column diameters would be at least 2 ft. Feed C and Feed D of Table 2 correspond to Feeds A and B of Table 1. Feed D represents the total feed to the depropanizer where Feed C is the net feed and two volumes of 12-lb RVP gasoline are recycled to the still per volume of net gasoline product.

Fig. 6 shows the results of this comparison and is similar to Fig. 4. The ratio of propane to isobutane in the feed is ordinarily greater than 1.0 for natural gasolines, but the curves were extended to a ratio of 0.3/1 to include many refinery operations. The inverted series compared with the direct series has in general higher fixed charges and lower operating costs. Reflux rates for the inverted series are about 5 per cent lower than those for the direct series. The higher pressure-level of the inverted series in Figs. 5 and 6 apparently has little significance in the pressure range of 50 to 215 psi.

The following conclusions are obtained from Fig. 6:

(1). If the propane concentration in the deethanized feed is relatively high, say more than 20 per cent, the direct series is recommended.

(2). If the propane concentration in the deethanized feed is relatively low, say less than 10 per cent, the inverted series is recommended.

(3). If the deisobutanized gasoline amounts to more than 80 per cent of the deethanized feed, the inverted series is recommended.

(4). For cases not covered by the above recommendations, either series may be used with very little difference in cost.

● **Deethanizing and depropanizing operations.** The removal of ethane-and-lighter fractions and propane from natural gasoline may also be compared with respect to the direct series and the inverted series operations, analogous to the sequences shown in Figs. 3 and 5. The significant difference is the large change in the pressure level of direct series and inverted series of this case.

The comparison of the direct and inverted series for deethanization and depropanization is limited to a comparatively small range of ethane/propane ratios in the feed because of external factors that are not present in the previous comparisons. If the ethane/propane ratio is greater than approximately 0.6/1, the large amount of ethane and the accompanying methane makes it im-

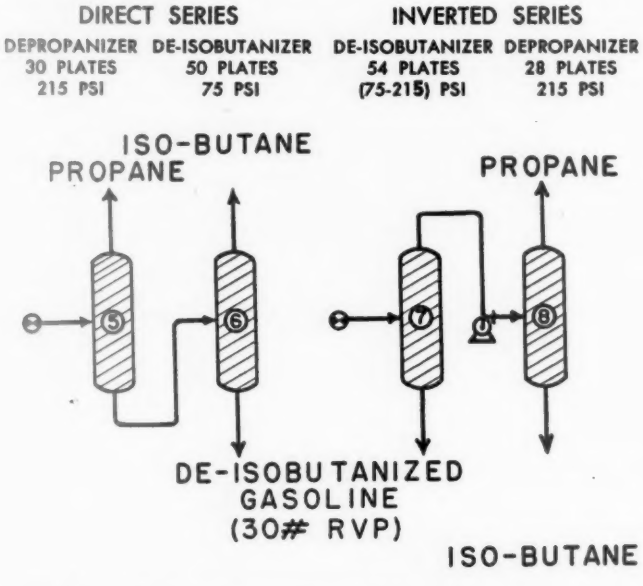

FIG. 5. Sequences of depropanizing and de-isobutanizing operations.

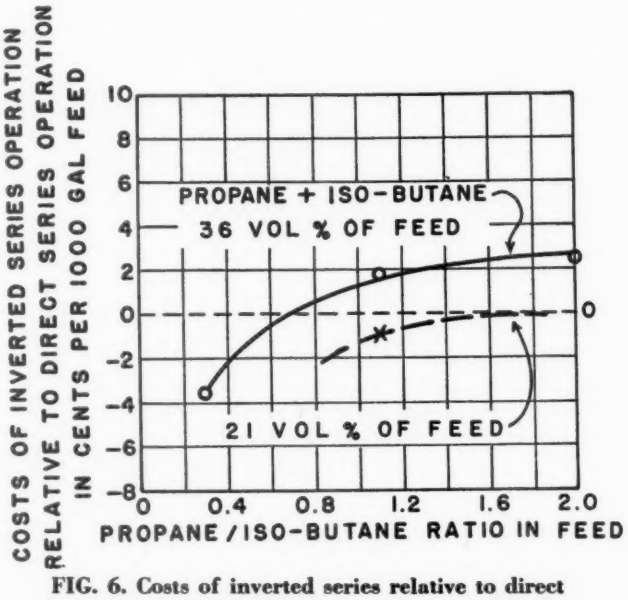

FIG. 6. Costs of inverted series relative to direct series for production of propane, iso-butane, and de-isobutanized gasoline (RVP-30 lb.).

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FIG. 7

CONCLUSIONS FOR NATURAL GASOLINE PLANTS

1. REMOVAL OF ETHANE AND PROPANE
   A. NEW PLANT—USE DIRECT SERIES.
   B. ADDITION TO PLANT WITH EXISTING DEPROPANIZER, USE INVERTED SERIES, IF ETHANE CONTENT IS NOT TOO HIGH.
2. REMOVAL OF ISO-BUTANE AND NORMAL BUTANE (NEW PLANT OR ADDITION TO EXISTING PLANT)
   A. USE DIRECT SERIES (OPTIONAL).
   B. IF HAVE LARGE GASOLINE RECYCLE TO STILL, USE INVERTED SERIES.

possible to obtain complete condensation at 100 F and 450 psig of the overhead product of the first column in the inverted series. A compressor must be used to feed the second column in the inverted series. The qualitative comparison given in Table 3 indicates that the direct series is preferred from an economic viewpoint.

On the other hand, if the ratio of ethane/propane in the feed is less than 0.25/1, as is the condition where deethanization of rich oil is employed in the absorbing-stripping cycle[11], it is possible to withdraw commercial propane as a sidestream from the deethanizer. This is due to the high volatility of ethane referred to propane (about 2.5/1). The one column operation, withdrawing propane as a sidestream, requires a fired reboiler or about 400 psi steam, but this is more than compensated for by the saving of one distillation column and its auxiliary equipment.

It is believed necessary to compare the inverted series with the direct series only when the ethane/propane ratio in the feed is between 0.25 and 0.60. One actual comparison at the ratio of ethane/propane = 0.32 (ethane plus propane being 23 per cent of the feed) indicates that the cost of inverted series relative to direct series operation is about + 40 cents per 1000 gal of feed. This incremental cost is due to the higher pressure column and the additional pumps required for the inverted series.

It is recommended that in a new plant, the ethane-and-lighter fractions of the natural gasoline be removed in the first column of the distillation series.

Many existing plants do not separate ethane from propane, either because of the small ethane content or the desired low recovery of commercial propane. If it becomes necessary to install a deethanizer because of anticipated higher ethane concentrations or desired increased recovery of propane, two general recommendations can be made:

(1). The use of the inverted series is more economical if the overhead product from the existing column can be completely condensed, because of the smaller diameter needed for the new deethanizing column. Many plants have found it possible to use sections of pipe for such a deethanizing operation, the pipes being either packed or fitted with piston-type bubble plates.

(2). If the overhead product from the existing column cannot be condensed, it is believed that direct series is more economical, although this case should be investigated for each specific separation. If direct series operation is to be used, the new column must operate at 450 psi and be sufficiently large to handle the large liquid load. If inverted series be used, compressors are required to feed the second column, and the new column must operate at 450 psi but will have a smaller diameter because of the smaller liquid load.

● **Summary and general conclusions.** The overall operation of distillation sections containing three or four columns may be considered by combining the "unit" studies made above. General conclusions for typical natural gasoline plants are indicated in Fig. 7.

Conclusions reached in the unit studies also apply to many refinery operations. For example, the feed to the distillation section of a typical butane-alkylation unit has a low propane/isobutane ratio, a high isobutane/n-butane ratio, and a small concentration of gasoline. Figs. 4 and 6 indicate that the preferred sequence of distillation is separation between isobutane and n-butane in the first column, with the overhead product sent to a depropanizer, and the bottoms product sent to a debutanizer.

The rule-of-thumb saying so often heard, that it is better to reduce the pressure level of the distillation system as soon as possible (implying direct series operation), appears to be generally true only for large increments of pressure in the high pressure range above about 200 psi. In other cases, the relative amounts of the products is the deciding factor. If the lightest product is present in large amounts, direct series is preferred; if the heaviest product is present in large amounts, inverted series is preferred.

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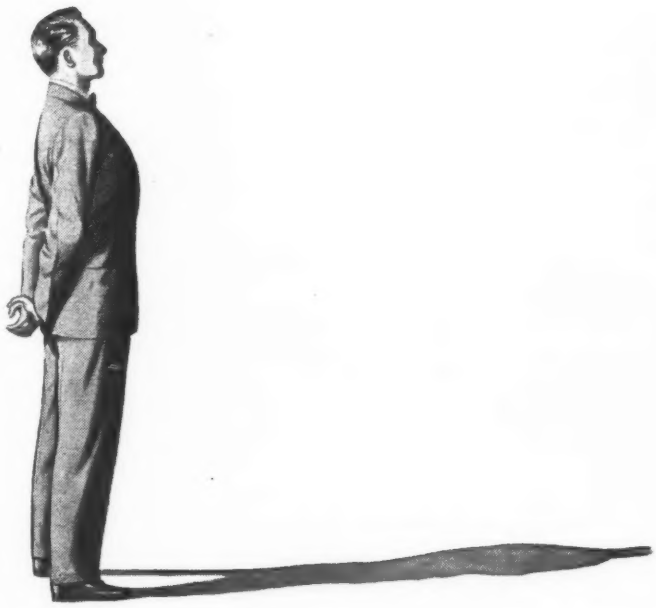

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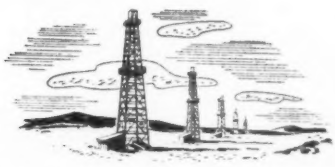
3. That you are providing good jobs, today, for more than 6,000 men and women... with a payroll that has increased to 210 times its original size?

4. That half of your employees have been with you for 10 years or longer and a fifth of them over 20 years—all enjoying uninterrupted work and personal security under the group insurance, hospitalization and retirement plans?

★ ★ ★

5. That the 121 wells you started with have increased to nearly 8,000?



6. That your annual production has multiplied over 35 times... with such operations, today, in 17 states?

★ ★ ★

7. That the pipelines you own have grown to a length of 4,000 miles... carrying more than 120 million barrels of crude oil annually?

★ ★ ★

8. That you have two refineries, processing over 7 million barrels of crude oil per year—with a program of modernization and expansion of refining facilities now under way?

★ ★ ★

9. That you are one of the largest among thousands of fine, independent companies in a highly competitive field?

10. That you are part of a great industry that has contributed so much to the growth of the America we know...to better, happier, healthier living?

★ ★ ★

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Method for predicting failure of metals*

By P. E. CAVANAGH†, *President*, Cyclograph Services, Ltd.

● **Synopsis.** This paper presents a discussion of the possibilities of using changes in high-frequency magnetic and eddy-current losses to predict failure in metals.

The method of recording changes in total magnetic and eddy-current losses (or "core losses") is described and examples of stress-core loss curves obtained are given.

Proof of the fact that this method will detect the beginning of plastic deformation due to overloading or fatigue leads to a practical application in the inspection of mine-hoist cable.

IN A PREVIOUS paper,[1] the author has described the use of high-frequency magnetic and eddy-current losses to compare stresses in metals. Various practical applications of this principle were discussed. One of the most interesting possibilities raised was the prediction of fatigue failure before it occurred.

In order for any type of failure to occur in metal some permanent distortion of the crystal lattice must take place beforehand. This distortion will change the magnetic and electrical properties and is detectable with sufficiently sensitive instruments[2, 3]. The Du Mont Cyclograph has been found to be a satisfactory tool in this connection, having stability, sufficient sensitivity, and great flexibility in the choice of test frequencies[4].

The auxiliary equipment used in the present investigation is shown in Fig. 1. The Cyclograph test coil was placed around the sample in the tension testing machine. The change in Cyclograph output (that is, total magnetic and eddy-current losses or core losses) was recorded on an Esterline-Angus meter. The meter recorder paper could be driven at a rate proportional to stress by the means shown in Fig. 2, or proportional to strain by suitable connections to the moving head of the tension testing machine.

Some typical stress-core loss or stress-Cyclograph curves for ferrous and nonferrous metals obtained by the above method are compared with stress-strain curves in Fig. 3. Note should be made of the changes in slope of the stress-core loss curves at points well below those at which clear changes from linearity occurred in the stress-strain diagrams. The changes in slope are probably related to the limits of proportionality of the materials tested. Further work is in progress to settle this question. Fig. 4 illustrates the sharp response of this method to the beginning of plastic deformation in brass.

A piece of metal will exhibit a certain relationship between total magnetic and eddy-current losses and small increases in applied stress below the elastic limit. This relationship appears to hold only so long as the metal has not been plastically deformed. If the metal has been plastically deformed, a new relationship is created. On this account, it is possible to distinguish between unworked and worked samples of the metal, given that a specimen of known charactertistics is available. On this basis, all further work has been founded.

The above is not true for magnetic materials, unless the magnetic domains are always initially in the same condition of random orientation or complete align-

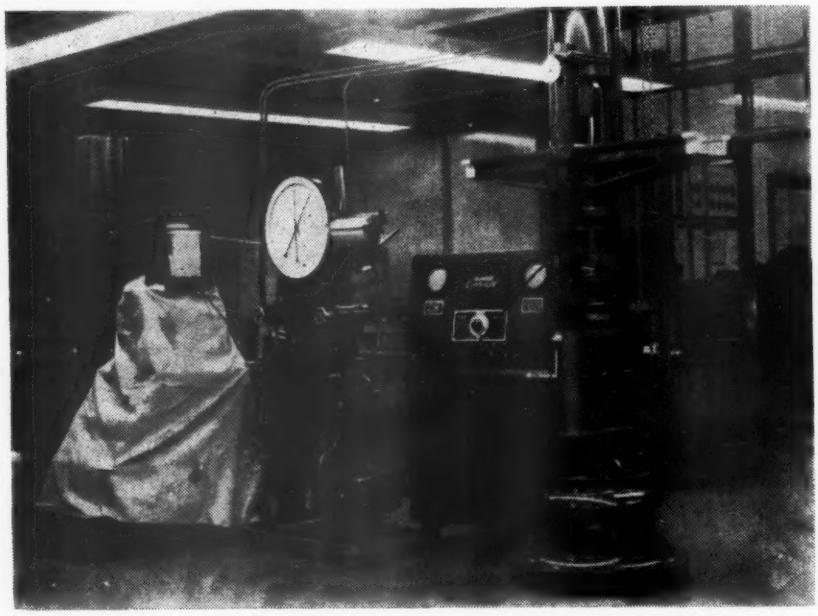
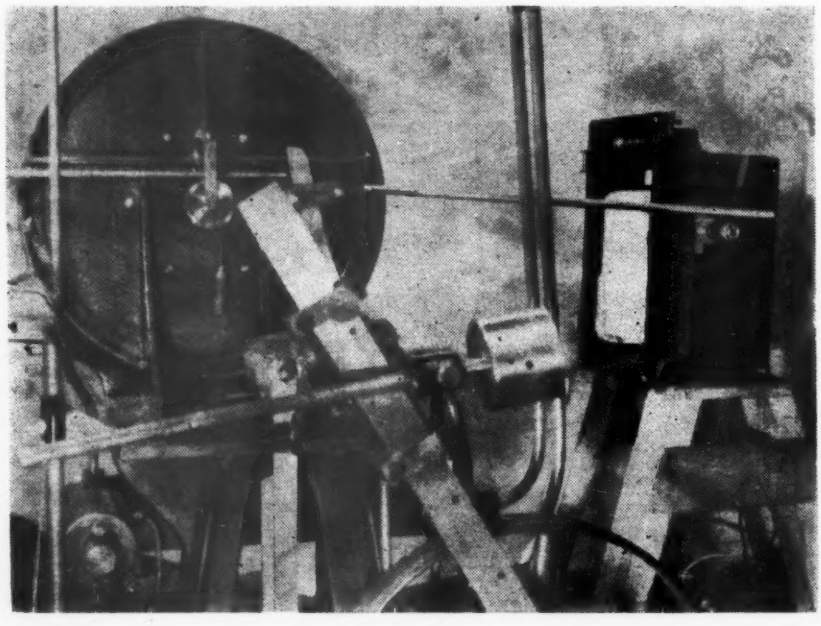


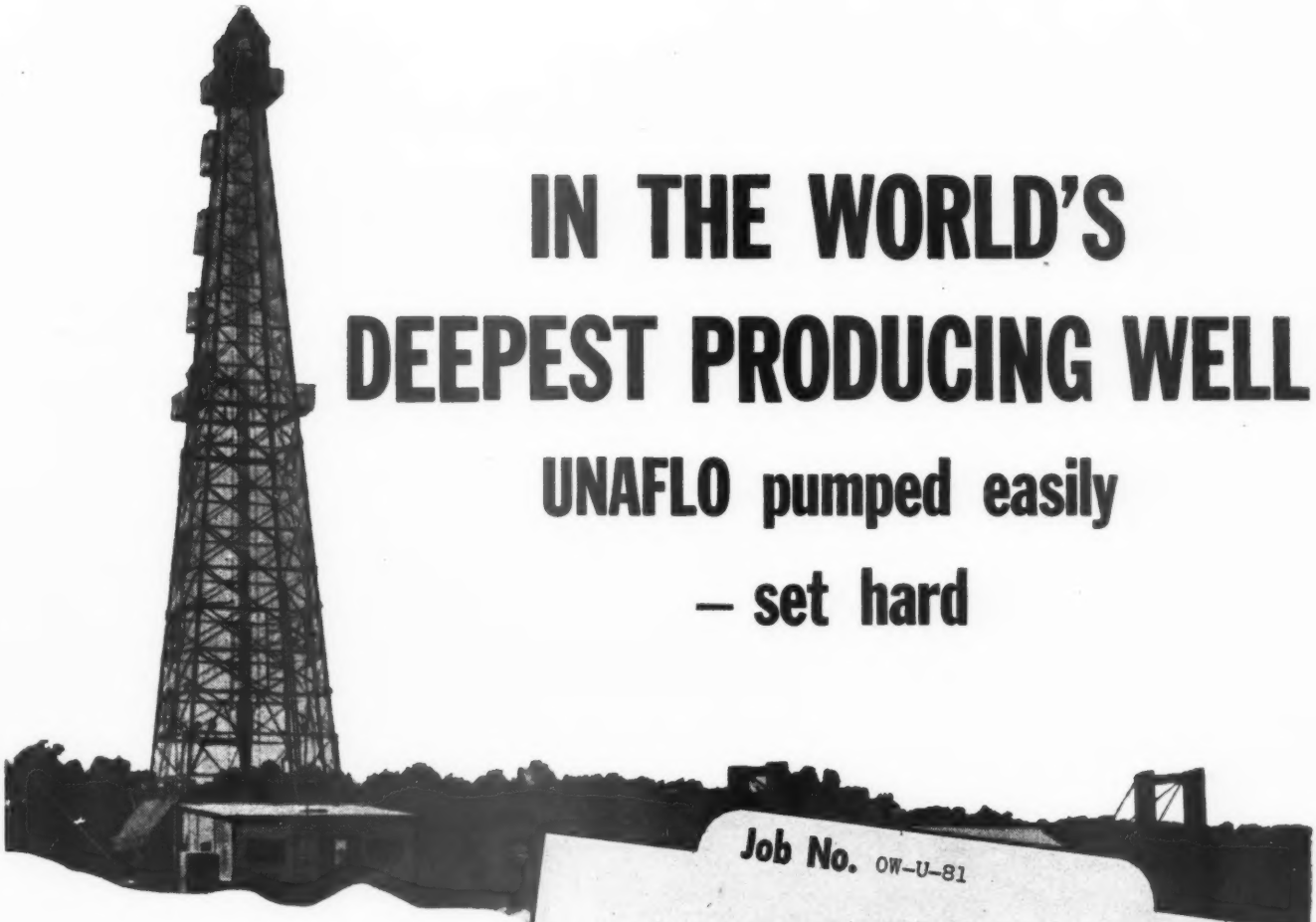
FIG. 1. Cyclograph with coil in place around tension specimen in Amsler machine. Esterline-Angus 1-mil. recorder driven from Amser records output.

FIG. 2. Ratchet attachment on hydraulic counterweight arm drives recorder paper proportional to stress. Spur on recorder gear prevents reversal of paper.



*Presented at 49th annual meeting of American Society for Testing Materials in Buffalo, New York, June, 1946. Published in *ASTM Bulletin*, December, 1946.

†At the time of the report, the author was research fellow, Ontario Research Foundation, and consulting metallurgist, Allen B. Du Mont Laboratories, Inc. His present firm, Cyclograph Services, Limited, is in Toronto, Canada.



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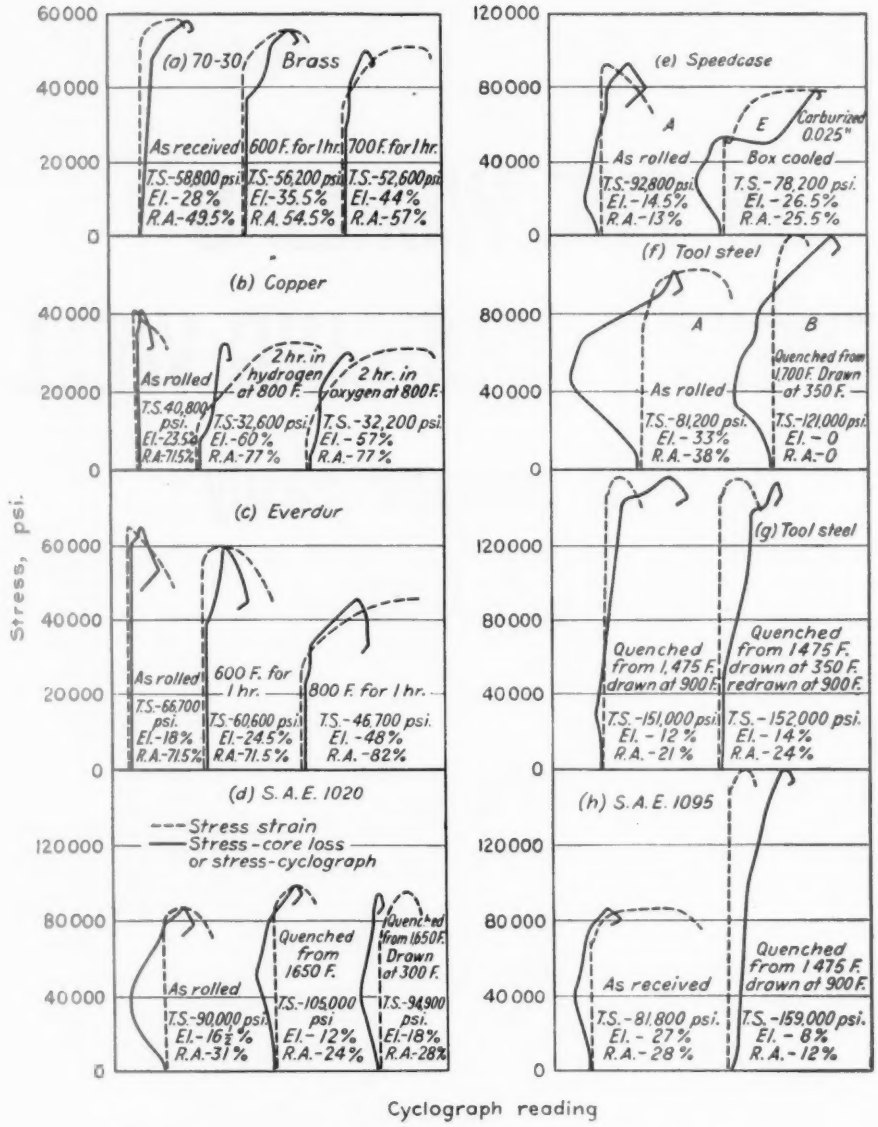

(a) 70-30 Brass
As received T.S.-58,800 psi El.-28% R.A.-49.5%
600 F. for 1 hr. T.S.-56,200 psi El.-35.5% R.A. 54.5%
700 F. for 1 hr. T.S.-52,600 psi El.-44% R.A.-57%
(b) Copper
As rolled T.S. 40,800 psi. El.-23.5% R.A.-71.5%
2 hr. in hydrogen at 800 F. T.S.-32,600 psi El.-60% R.A.-77%
2 hr. in oxygen at 800 F. T.S.-32,200 psi El.-57% R.A.-77%
(c) Everdur
As rolled T.S.-66,700 psi. El.-18% R.A.-71.5%
600 F. for 1 hr. T.S.-60,600 psi El.-24.5% R.A.-71.5%
800 F. for 1 hr. T.S.-46,700 psi. El.-48% R.A.-82%
(d) S.A.E. 1020
---Stress strain
——Stress-core loss or stress-cyclograph
As rolled T.S.-90,000 psi El.-16½% R.A.-31%
Quenched from 1650 F. T.S.-105,000 psi El.-12% R.A.-24%
Quenched from 1650 F. Drawn at 300 F. T.S.-94,900 psi. El.-18% R.A.-28%
(e) Speedcase
A As rolled T.S.-92,800 psi El.-14.5% R.A.-13%
E Box cooled T.S.-78,200 psi. El.-26.5% R.A.-25.5%
Carburized 0.025"
(f) Tool steel
A As rolled T.S.-81,200 psi. El.-33% R.A.-38%
B Quenched from 1700 F. Drawn at 350 F. T.S.-121,000 psi. El.-0 R.A.-0
(g) Tool steel
Quenched from 1475 F. drawn at 900 F. T.S.-151,000 psi El.-12% R.A.-21%
Quenched from 1475 F. drawn at 350 F. redrawn at 900 F. T.S.-152,000 psi. El.-14% R.A.-24%
(h) S.A.E. 1095
As received T.S.-81,800 psi. El.-27% R.A.-28%
Quenched from 1475 F. drawn at 900 F. T.S.-159,000 psi. El.-8% R.A.-12%
Stress, psi.
Cyclograph reading

FIG. 3. Comparisons of stress-strain and stress-core loss curves. All samples standard ½-in. diameter tension specimens.

ment. The alignment of magnetic domains by external stress produces the initial rapid increase of total core losses shown in the curves of Fig. 3 for ferrous materials[5]. In repeated tests on the same sample, vibrating the sample after stressing within the elastic range will bring the domains back to a state of random orientation when external stress is removed, so that further tests may be made on a comparative basis. This procedure must be carefully followed in all tests on ferrous metals.

The changes in magnetic properties in a ferro-magnetic material under stress can be more clearly understood if the conditions existing are considered in in three separate stages in detail:

1. When small stresses are applied to a ferro-magnetic material, the first effect on the magnetic properties is due to the gradual alignment of magnetic domains. This phenomenon is the reverse of magnetostriction. A saturation point is reached when all the domains are in complete alignment. For an average ferro-magnetic material, this occurs at an external stress somewhere between one third and one half the yield point. Removal of external stress allows the domains to return to a condition approximating their original random orientation. The original condition will never be exactly duplicated, because of inertia or hysteresis effects in the movement of the domains. However, the resulting slight difference in magnetic properties from the original is hardly detectable by the Cyclograph at usual operating sensitivities even in hard ferro-magnetic materials where the hysteresis effect is most pronounced.

2. If external stress greater than that necessary to produce complete alignment of the domains but less than that which will produce plastic deformation is applied, a quite different effect is seen when the external stress is removed. The higher stress disturbs and possibly ruptures the bonds and inter-acting forces between domains. On removal of the external stress, the domains do not return to their original condition of random orientation but remain in partial or complete alignment. This condition produces a marked effect on the magnetic properties and can be readily detected by the Cyclograph.

The original random orientation can be reestablished by vibrating or hammering the sample.

3. If external stresses are great enough to produce some plastic deformation, internal stresses are set up in the metal that destroy the alignment of the domains and insure random orientation on removal of the external stress.

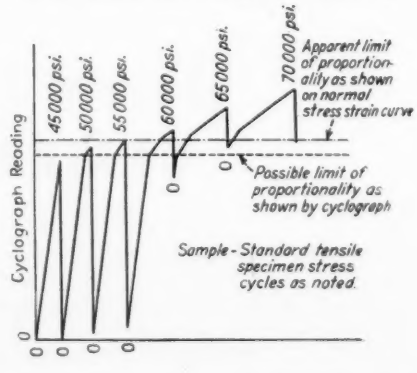
● **Failure due to overloading.** If a piece of metal has been previously loaded beyond the elastic range so that plastic deformation has taken place, the change in total core losses caused by a certain change in stress will be markedly different than the change for the same piece of metal if previous loading has not exceeded the elastic range. This is true whatever the rate of previous plastic deformation.

The curves in Fig. 5 demonstrate this fact. If the standard stress-Cyclograph curve has been determined for a particular size and analysis of metal, applying a standard load to a similarly shaped piece of the same metal will at any time determine whether or not it has undergone plastic deformation. Stress-Cyclograph curves can be obtained while the piece of metal is in service. In other words, this method of test allows one to make a periodic nondestructive check to determine whether the piece is beginning to fail due to overloading.

A stress-Cyclograph curve may indicate that a particular size and analysis of metal with same heat-treatment history differs from the standard. In all cases so far investigated, such differences appear to be related to incipient failure, however, tension tests of such materials may suggest that they have become stronger, due to the fact that plastic deformation has increased their resistance to tensile stress. In such cases, evidence of incipient failure is readily seen in reduced ductility as measured by percentage elongation or lower endurance limit.

● **Fatigue failure.** As described in a previous report[1], the Cyclograph can predict fatigue failure. There are definite

FIG. 4. Change in core losses in 70:30 brass under repeated loading.



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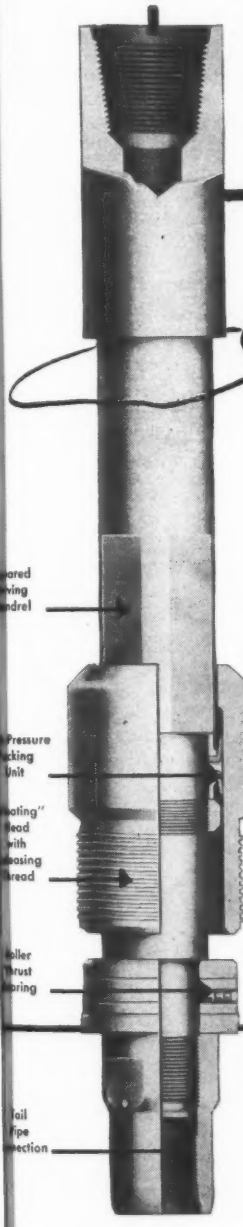
- ✔ *Sets Light or Heavy Liners with Same Simplicity!*
- ✔ *Also Sets Packers, Adapters and Other Accessories!*
- ✔ *Delayed Action Attachment Provides Additional Advantages!*



THE BAASH-ROSS SECURITY LEFT HAND RELEASING TOOL*

FOR positive fool-proof setting of oil well liners and accessories the Baash-Ross Security Releasing Tool is unequalled. Its unique operating principle holds the liner (or other accessory) firmly in place while the left hand connection is released . . . *and there is no risk of binding the left-hand back-off thread regardless of weight placed on the liner.*

HERE'S HOW IT WORKS . . . The liner, packer or other accessory is fastened to the Releasing Tool by a coarse left-hand thread. To release, the liner hanger slips are set in the usual manner (or the liner is set on bottom) and a few points of weight are then applied downwardly and the Tool rotated to the right until the connecting thread is unscrewed.

The liner is held firmly in position by the weight which is applied to the liner through a roller thrust bearing which seats against a shoulder on the device being set. The connecting thread is on a "free-floating" head which is driven by a squared section on the mandrel *but is free to move up the mandrel as the thread disengages.* There's no need to lift the run-in string while releasing—nor is there any risk of binding the threads at any time. All weight applied through the string is taken by the thrust bearing, thus simultaneously holding the set device firmly in place and relieving the connecting thread of any weight.

Ideal for Cementing and Washing Operations

The Baash-Ross Security Left Hand Releasing Tool not only simplifies liner and packer setting operations, but also facilitates washing and cementing operations run at the same time. The "floating head" is packed off to withstand high fluid pressures, preventing leakage at this point . . . and threads are provided for attaching any length of tail pipe to the bottom of the tool for spotting cement or washing action. No packer of any kind is needed on the tail pipe.

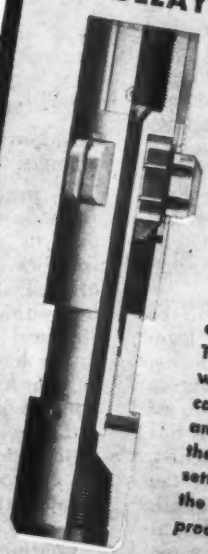
WIDE RANGE OF ACCESSORY EQUIPMENT

Many types of accessories are available for use with the Baash-Ross Security Releasing Tool—and also for use with the Delayed Action device. In all of these tools a special shoulder is provided for supporting the thrust bearing, and the connecting thread mates with that of the Releasing Tool In Delayed Action devices a special setting sleeve, actuated by the expanded lugs, is incorporated. Accessories include . . .

- **Adapters.** Plain, Regular Packing and Delayed Action Packing Types . . . plus a Regular Action Type with releasable hold down slips for pressure conditions. For all casing sizes 4¾" thru 13⅜".
- **Liner Hangers.** Plain, Regular Packing and Delayed Action Packing Types . . . plus a type with releasable hold down slips. For all casing sizes 4¾" thru 13⅜".

. . . and other accessories.

DELAYED ACTION ATTACHMENT HAS MANY USES



The Baash-Ross Security Delayed Action Packer Setting Tool attaches to the bottom of the Releasing Tool to give positive protection against prematurely setting packing elements on Delayed Action Adapters, Liner Hangers and Casing Packers. Lugs remain retracted within the walls of the Setting Tool until after all washing, cementing and other operations are completed. Then, after releasing, the Tool is lifted above the packing device, whereupon the lugs expand automatically. The run-in string is then lowered and as the lugs seat against the top of the packer the applied weight forces the setting sleeve downward and expands the packing. *It's simple, positive, fool-proof in its operation!*

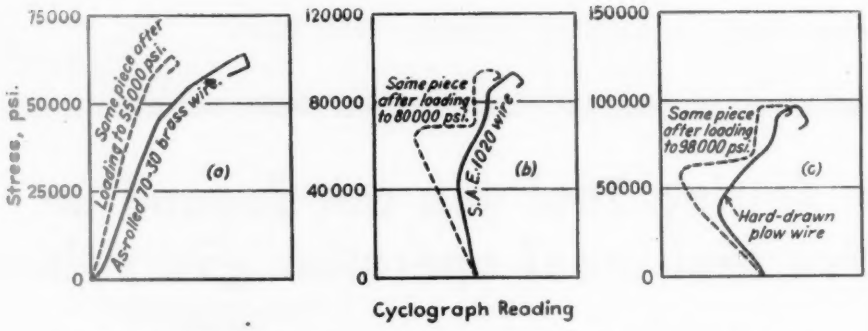


FIG. 5. Stress-core loss curves for same specimen before and after loading beyond the elastic limit. All samples were 0.050-in. wire.

limitations to this method of prediction, but its practical possibilities are very interesting. For example:

Fig. 6 illustrates the difference in rate of change of core losses during fatigue in two steel test specimens with different fatigue life after the fatigue test had proceeded for some time. The Cyclograph is not sensitive to cracks or flaws, hence the initiation of fatigue cracks has no appreciable effect on the instrument.

Samples of ferrous and non-ferrous metals were subjected to repeated unidirectional tension below the limit of proportionality but greater than that value at which the stress-Cyclograph curve changes slope. Stress-Cyclograph curves made after this repeated loading are compared with the original curves for the same test specimens in Fig. 7. This test is analogous to the working conditions in such structures as mine-hoist ropes. Repeated unidirectional stresses below the elastic limit may not weaken the rope, but will reduce fatigue life.

● **Prediction of failure in mine-hoist rope.** The foregoing demonstrates that high-frequency core losses can be used to detect incipient failure in metals where such failure is preceded by plastic deformation.

The continuous inspection of mine-hoist rope in service is a logical application of this test. A hoist rope in good condition, working at normal loads, will last indefinitely, however, corrosion, abrasion, bruising, and kinking may seriously weaken a rope locally and give rise to failure. Improper lubrication may also contribute to abrasion and fatigue.

Whatever the cause of failure, the unit stresses in the part of the rope where failure has started will be higher than in the rest of the rope. The higher unit stresses can be detected by the Cyclograph, for the core losses are different where the higher stresses occur.

Ultimately, the elastic limit will be exceeded in some or all of the load-carrying strands and some plastic deformation will take place. The stress-Cyclograph curve for this portion of the rope will then be different than it was before the elastic limit was exceeded, even though the tensile strength of the rope is not necessarily reduced. As failure proceeds, the Cyclograph reading at this point of incipient failure for some

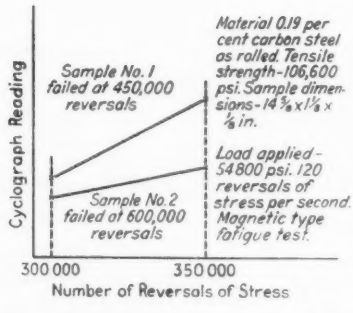

Cyclograph Reading
Sample No. 1 failed at 450,000 reversals
Material 0.19 per cent carbon steel as rolled. Tensile strength-106,600 psi. Sample dimensions-14 3/8 x 1 1/8 x 1/8 in.
Load applied-54800 psi. 120 reversals of stress per second. Magnetic type fatigue test.
Sample No. 2 failed at 600,000 reversals
300 000
350 000
Number of Reversals of Stress

FIG. 6. Change in core losses during fatigue test. From an investigation conducted at Rensselaer Polytechnic Institute[7].

record stresses in the rope. Such a record will also indicate whether safe working stresses are being exceeded in starting and stopping[6].

Field trials of this method of testing mine-hoist rope have been in progress for some time and will be reported on when completed.

● **Acknowledgments.** The author wishes to express his appreciation of the work done on this problem by R. S. Segsworth, General Engineering Company (Canada) Limited, Toronto, Ontario, Canada, and of the assistance given by O. W. Ellis, of the Ontario Research Foundation.

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2. "Effect of Cold Work on Electrical Conductivity of Copper Alloys," D. K. Crampton, H. L. Burghoff, and J. T. Stacy, *AIME Transactions*, Technical Paper 1290, Vol. 143, p. 228 (1941).
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(Discussion follows)

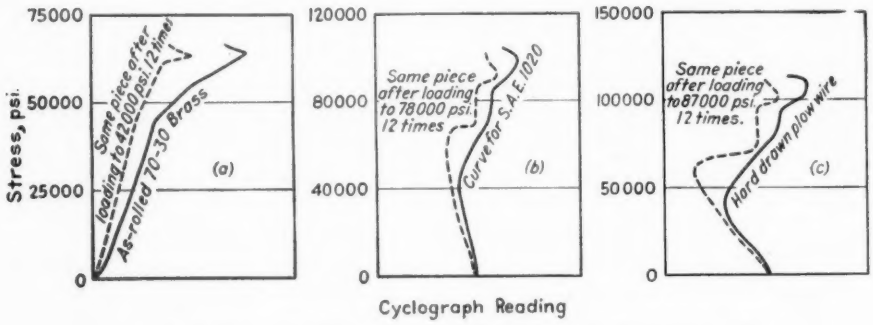

FIG. 7. Stress-Cyclograph curves before and after repeated loading in tension. All test specimens were 0.050-in. wire.

NOTE: *Recorder paper driven as shown in Fig. 2. Compare with Fig. 5 where paper reversed as stress decreased.*

standard rope load will continue to change.

In practice, a Cyclograph recording is made of the condition of the rope over its entire length when it is first installed, and at definite intervals thereafter. Tests must be made with a known load on the rope. Any variation from the standard recorded pattern at any point in the length of a particular rope at a definite load can only be due to the beginning of plastic deformation. A limit can be set for allowable variation of the instrument reading from normal (Fig. 8). A reading beyond this limit at any point in the rope will indicate that it is no longer safe to use.

Continuous inspection can be used to

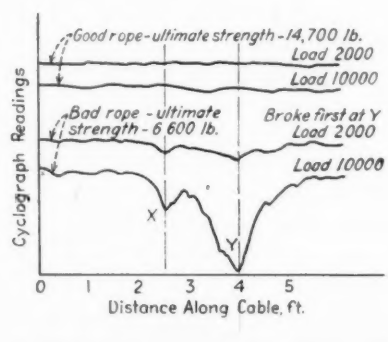

FIG. 8. Variations in recorded Cyclograph output in cable under load, using 5/8-in. 6-19 wire rope.

Discussion of "Method for Predicting Failure of Metals"

COMFORT A. ADAMS[1]: Has there been any attempt on the part of the author of this paper to explain these core losses in terms of the damage he refers to?

P. E. CAVANAGH: *(author):* The theoretical and fundamental basis of this work has been very ably covered in Germany in the last few years by Forster and Becker and in Canada by a member of the Bureau of Mines. As far as we are concerned, we have not as yet been concerned with finding out in a practical test whether damage is due to fatigue or due to overloading. We have had examples where we have tested cables that have been in service for a year and a half and we found that the recording deviated a great deal from what we expected. We took the whole cable and cut it into 6-ft lengths. Some of the lengths were tested and the ultimate strength of the rope was found higher than normal.

However, the fatigue life of that rope, although no fatigue tests were made on it, I imagine was very much lower than normal. There are many situations where the results of such tension tests are going to show that the ultimate strength of the rope is higher and that deformation has taken place. In no instances where the strength was raised did we make any fatigue tests. There is no distinction made as to the different types of damage. Only continuing change in reading which indicates continuing damage (of either type) is regarded as important. Plastic deformation may increase the strength of the rope locally and prevent further fatigue or plastic deformation. In this case no further change in reading would occur at this point.

ADAMS: Did the core loss increase or decrease with damage?

CAVANAGH: It increases with damage if you are testing a magnetic material.

ADAMS: You showed some curves with peaks higher and higher, day after day.

CAVANAGH: The core loss was increasing.

ADAMS: That high core loss place was the place where it broke? Is that it?

CAVANAGH: Yes. If the damage is increasing, the core loss is increasing.

O. W. ELLIS[2]: There is now some evidence that these tests are going to be of practical value. At the present time the testing of mine ropes involves their partial destruction. If by a nondestructive type of test like this the presence of defects in ropes can be detected, so much the better.

I should like to mention one fact that impressed me in the work going forward on the small test equipment at the Ontario Research Foundation. In one of the curves of the type shown in Fig. 8 of the paper a defect was indicated as being present at a certain point in a rope. We, being inexperienced in the ways of mine cables and wire ropes, were quite unable to detect visually any defect in the rope at the point so clearly indicated by the Cyclograph.

It so happened that two or three days later members of the staff of the Department of Mines of the Province of Ontario came in to witness the test then proceeding. Their expert knowledge of the ways of wire ropes caused them to search along the length of the rope in the vicinity of the place where failure seemed to have occurred. One of the experts then noticed a slight, apparently unimportant, superficial defect at a point about four inches away from the place where the defect showed up on the Cyclograph chart. He took out his penknife and began picking away at the defect he had detected and eventually pulled out a wire that had broken at the point where the Cyclograph had indicated failure had occurred. This constituted rather impressive evidence that something had happened four inches from where a defect was apparent on the surface of the rope—something which had been shown up on the Cyclograph. I think there are great possibilities for this test, but there remains a tremendous amount of work to be done before we know exactly what the instrument is measuring.

H. F. MOORE[3]: As I understand it, it is not feasible with this apparatus to distinguish between cold work and fatigue damage to a metal. I understood the author to say that he assumed that if cold work had been done, the strength of the metal under *static* load would be increased, at least in most cases. From the experience we have had with cold work at the University of Illinois we should agree with that statement, but under repeated load, cold work if not too severe increases static elastic strength, increases tensile strength to a less degree, and if not too severe, or too often repeated, also increases the fatigue strength somewhat. I should like to ask the author if he feels that with his apparatus he can detect surely whether *fatigue damage* has been done to a metal.

CAVANAGH: I should say you can surely detect that there has been a change in the physical properties. As to whether the fatigue life has been increased or decreased, I am sure you know more about that than I do. Our feeling was that the rope had been damaged. It did not show up in the regular tension test. As a matter of fact, it may not have been damaged in fatigue. It may just have been changed. Under random fatigue overloads such as might be met in hoisting operations, it would be impossible to say that fatigue life would be reduced in every instance by overloads. There is some change in properties going on in the rope and that is all we know from these tests.

PAUL A. BECK[4]: I think it would be quite interesting to correlate the Cyclograph results with fatigue tests. If it is possible to predict fatigue failure by this method, it could be used for periodic inspection of propellers and machine parts which usually fail by fatigue.

CAVANAGH: We are very much interested in the possibility of predicting fatigue failure in normal fatigue tests. I do not see a great deal of practical application in this field myself but others might. We have used the instrument in some special instances to try to do just that, but our results are not yet completed. Some of them are extremely interesting. We are proceeding slowly so as to be quite sure of what we are doing before drawing any conclusions.

We have been using the instrument on some rolling load tests for rail fatigue, for instance, and have found some very interesting changes in slope of our curve before the rail shows cracks on the compression side. What that means, we are not prepared to say yet.

We are also conducting tests on a rotating-beam fatigue machine and find some interesting changes in slope in these tests before we can detect any failure by normal methods. I am afraid that any conclusions on those results will have to wait until we have collected a great deal of data.

ADAMS: What frequency was employed?

CAVANAUGH: Between 2000 and 200,000 cycles per second. The particular frequency for any test is chosen to give nearly linear correlation between core losses and stress, and as great a flux penetration as possible.

ADAMS: The electromagnetic phenomena in the cylindrical specimen, the wire, under those frequencies, are pretty definitely computable and particularly at the higher frequencies are confined very largely to the skin of the material. The reason for my first question as to the connection between the two, was connected with that fact. The more you know the reason why of things, the more you can figure them out, the better able you will be to interpret the results intelligently. I think there are great possibilities there.

CAVANAGH: That is being done. We are working now on the theoretical ex-

[1]Consulting Engineer, Edward G. Budd Manufacturing Company, Philadelphia, Pennsylvania.

[2]Director, Department of Engineering and Metallurgy, Ontario Research Foundation, Toronto, Ontario, Canada.

[3]Research Professor of Engineering Materials, Emeritus, University of Illinois, Urbana, Illinois.

[4]Associate Professor of Metallurgy, Notre Dame University, Notre Dame, Indiana.

plantations for the results we are obtaining. Some of that work is being done in conjunction with Mr. Wlodek at the Bureau of Mines in Ottawa, Canada, and I believe we will have some material soon.

ADAMS: Most of your defects are on the outside of the cable, are they not?

CAVANAGH: Most defects do occur on the surface of a cable but internal defects are also detectable at the frequencies between 2000 and 5000 cycles. We choose frequencies to give us the results we want. For larger cables the frequencies run around 3000 or 4000 cycles, which apparently gives us sufficient penetration to detect defects through the entire cable.

ADAMS: What size cable?

CAVANAGH: Up to 1¼ in. At the low flux density used, permeability is quite low, giving many times the penetration usually obtained at these frequencies using stronger fields. You do get much more penetration in stranded cable than you do on the solid bar, a great deal more. You don't get anything like as much at the higher frequencies and of course it is not uniformly distributed over the section. Even at 1000 cycles, you get much less flux density in the center of the field. One interesting feature about the little incident to which Mr. Ellis referred was the fact that the defect detected was in the interior. One fundamental thing we emphasize is the fact we are not detecting defects in the wire. We are detecting an increase in stress. If a wire is carrying more than its share of load, the unit stress is higher. Actually an interior defect throws more stress on the outer wires, outer defects throw more on the interior wires. Some problems are made a little simpler by these facts than at first appears.

BURT L. NEWKIRK[5] *(by letter):* Several of our students at Rensselaer Polytechnic Institute have made studies and tests on the general problem of finding some nondestructive test of the progress of fatigue of metal. All used the same means of fatiguing the specimens. This consisted of two columns supporting on knife edges a piece of cold-rolled steel ⅛ in. thick, 1 or 1⅛ in. wide, depending on stock available, and approximately 14⅝ in. long. An electromagnet set under the middle of the specimen was energized with 60-cycle current, and caused the specimen to vibrate near resonance at 120 cycles with an amplitude that could be adjusted and measured with fair accuracy.

K. F. Paulovich first tried to determine whether the progress of fatigue was accompanied by changes in the frequency of natural vibration of the specimen. He found some variation as fatigue progressed but this was not confirmed by subsequent studies, which showed very little change in natural frequency up to the time when fine surface cracks could be found with a microscope, or by a Magnaflux test. For one specimen, after the natural frequency had dropped only one and one-half cycles per second, a tension test showed the characteristic fatigue fracture over almost half the area of the break. This suggested a progressive embrittlement along certain areas within the metal, rather than progressive fracture, developing through any considerable fraction of the fatigue history of the specimen. Any progressive fracture would certainly have made observable changes in the natural frequency of the specimen.

J. B. Duke (Ref. 7) using the Du Mont Cyclograph, measured the core losses of the specimens at successive stages of fatigue. This was done for specimens in the cold-rolled condition and for other specimens from the same strip that had been annealed. Changes were noted in both lots, but in opposite directions. Mr. Cavanagh has suggested an explanation for this behavior (Ref. 1). The changes observed for the annealed specimens were quite regular and progressive. This finding seems to be supported by Cavanagh's finding that plastic changes affect readings made with the Cyclograph. In Duke's work, the plastic deformations must have been very minute, since it took about half a million reversals to produce the first detectable cracks.

[5]Professor of Vibrations, Theoery and Practice, Rensselaer Polytechnic Institute, Troy, New York. ★★★

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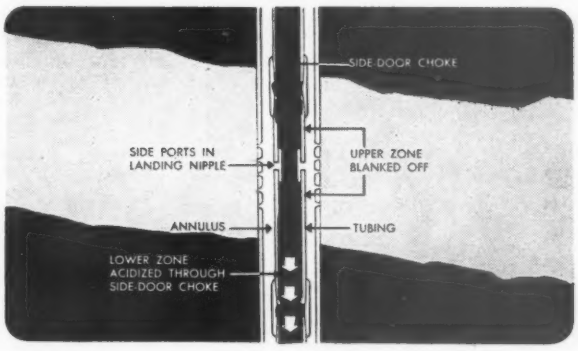
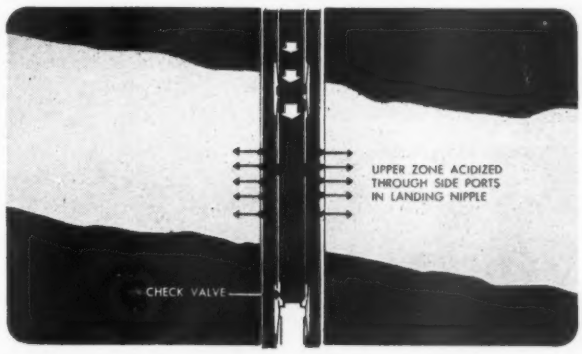
Use of Otis Side-Door Chokes for dual-completion and acidizing becomes standard practice in East Texas fields

1 "The use of Otis dual-completion equipment in acidizing and completing two-zone wells has proven so successful during the past few years that the majority of operators in this territory now accept it as standard operating procedure. This is especially true around the Carthage area. A typical operation of this type was on a 6200-foot well completed by the Blank Corporation last June. They contacted our Longview office and we delivered a Type L Landing Nipple to the well site.

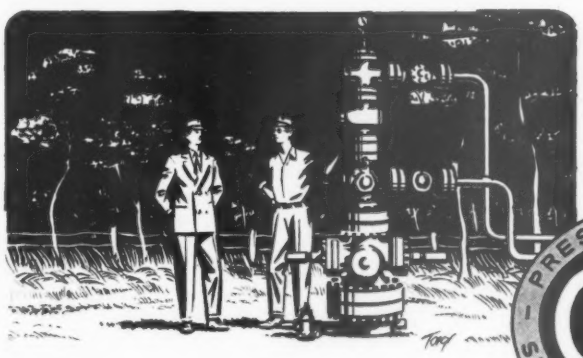
2 "After the packer had been set, the tubing was landed with the Type L Nipple located in the upper zone at 6132 feet. Surface connections were permanently installed while the well was still loaded with mud. Then, by establishing circulation between the casing and tubing through the four ½-inch ports in the Landing Nipple, the annular space was easily unloaded. This eliminated all risks of trying to acidize and bring the well in before the packer was set and surface controls were hooked up.



3 "An Otis service crew then rigged up our high-pressure lubricator and wire line equipment (well pressure was 2700 p.s.i.) and ran a 2½" Type L Side-Door Choke on a steel measuring line. With the Side-Door Choke seated in the Landing Nipple the fluid course from the annulus to the tubing was blanked off by respective sets of pressure-seal packing located above and below the side ports. Thus, with the upper sand blanked off, acid was pumped through the tubing and Choke and into the lower sand.



4 "After the Side-Door Choke was pulled the well was allowed to clean itself. We then made up an Otis Check Valve on our line and ran it to the bottom of the Type L Landing Nipple to plug all downward flow. (The tool itself is a drop check valve mounted on a packing mandrel. One set of packing prevents downward flow from entering the lower zone around the valve). With the lower zone blanked off, acid was pumped down the tubing and out through the side ports in the nipple into the upper zone. The Check Valve was then pulled.



5 "After both zones had been successfully acidized the Type L Side-Door Choke was re-run and locked in the Type L Landing Nipple. Through this installation the lower zone is now producing through the Side-Door Choke, while the upper zone is producing through the annulus—and the well is permanently equipped with side ports which can be easily opened and closed without moving the tubing should it become necessary to kill the well, re-acidize, take bottom-hole pressures of either zone through the tubing, etc."

This is the sixth in a series of advertisements describing actual installations of Sub-Surface Controls and subsequent service by Otis Pressure Control, Inc. For further details on equipment and service, write Otis Pressure Control, Inc., P. O. Box 7206, Dallas.

(T-7)

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Fire extinguisher mounted in truck

By O. C. Irvine, United Gas Pipe Line Company

EXCLUSIVE

THE Dugas type fire extinguisher has proved to be an important adjunct to maintenance truck equipment for use on gas fires encountered in repairing pipe line leaks or breaks. It also affords protection for employes engaged in making hot taps or performing other operations wherein gas in a bell hole might become ignited.

When mounted on the truck and carried as standard equipment, a fire extinguisher cannot be overlooked and left behind in an emergency. Among the chief obstacles to carrying this kind of equipment, however, has been the lack of a suitable mounting or carrying holder that would protect the extinguisher against damage in hauling and at the same time make it readily accessible for emergency use.

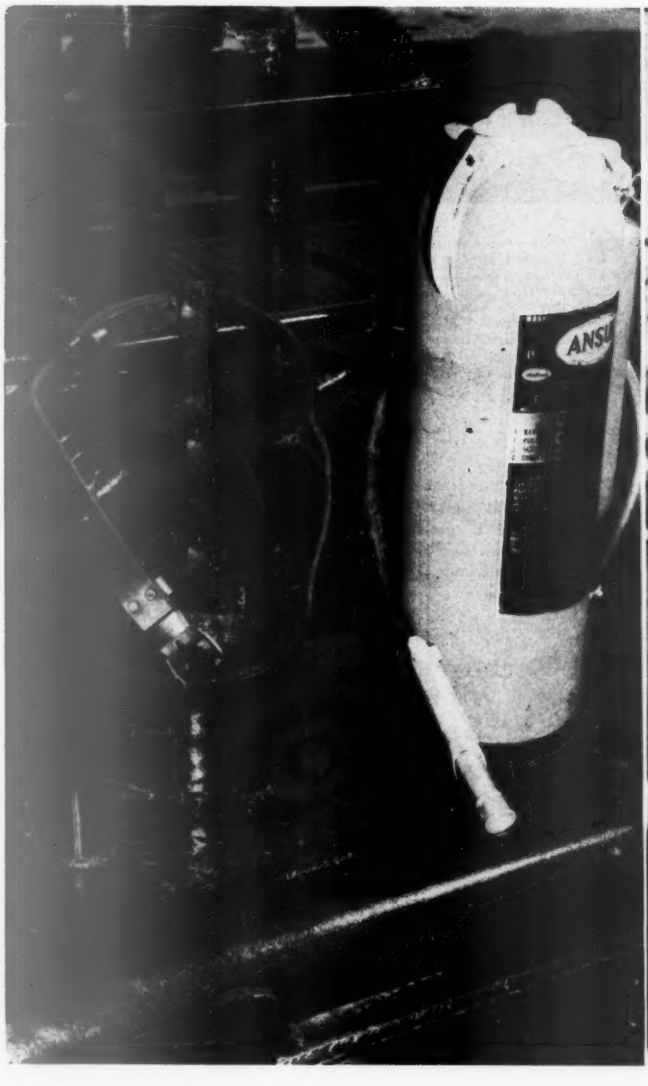
This difficulty was recently overcome for maintenance trucks of the United Gas Pipe Line Company when M. E. Bennett, foreman of United's Shreveport, Louisiana, garage, perfected his design of the carrier bracket illustrated in the accompanying photographs.

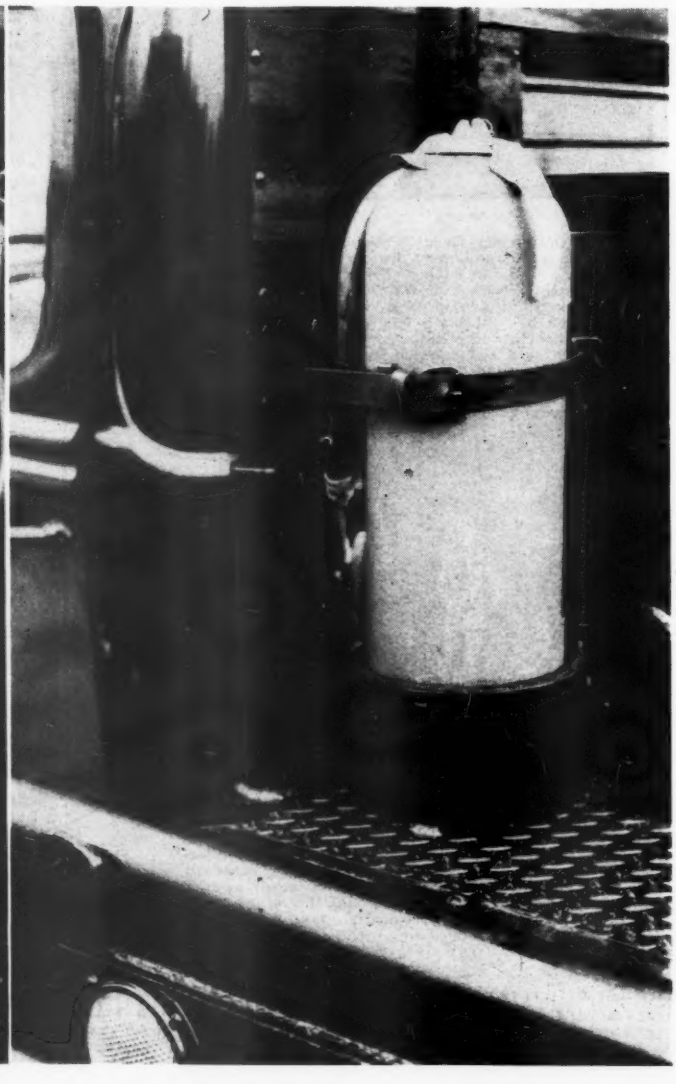
The bracket, which holds the extinguisher in a rigid upright position and is insulated with soft rubber to offset the constant vibration and jolting of the average pipe line truck, was built principally of scrap materials. The base, fashioned of a piece of 8-in. line pipe 5 in. in height, is electrically welded to the metal bed of the truck on the side nearest the driver and at a point offering the least obstruction to loads the truck will handle.

Three ½-in. by 3-in. vents flush with the truck bed prevent accumulation of water in the base. Three ⅛-in. rubber-cushioned flat iron ribs form a seat for the extinguisher inside the circular base, which is also lined on its inside walls with two ½-in. by ¾-in. sponge rubber strips secured in place by four clamps. (See photos below.)

An upright brace to which securing buckles and leather straps are attached is of flat iron 1¼ in. wide, welded to the base, also rubber cushioned and extending 11 in. upwards from the top edge of the base.

Dimensions and assembly of the bracket described are for an Ansul model 30 Dry Chemical Fire Extinguisher. These would have to be varied according to type and size for other extinguishers. ★ ★ ★





Alloy Steels

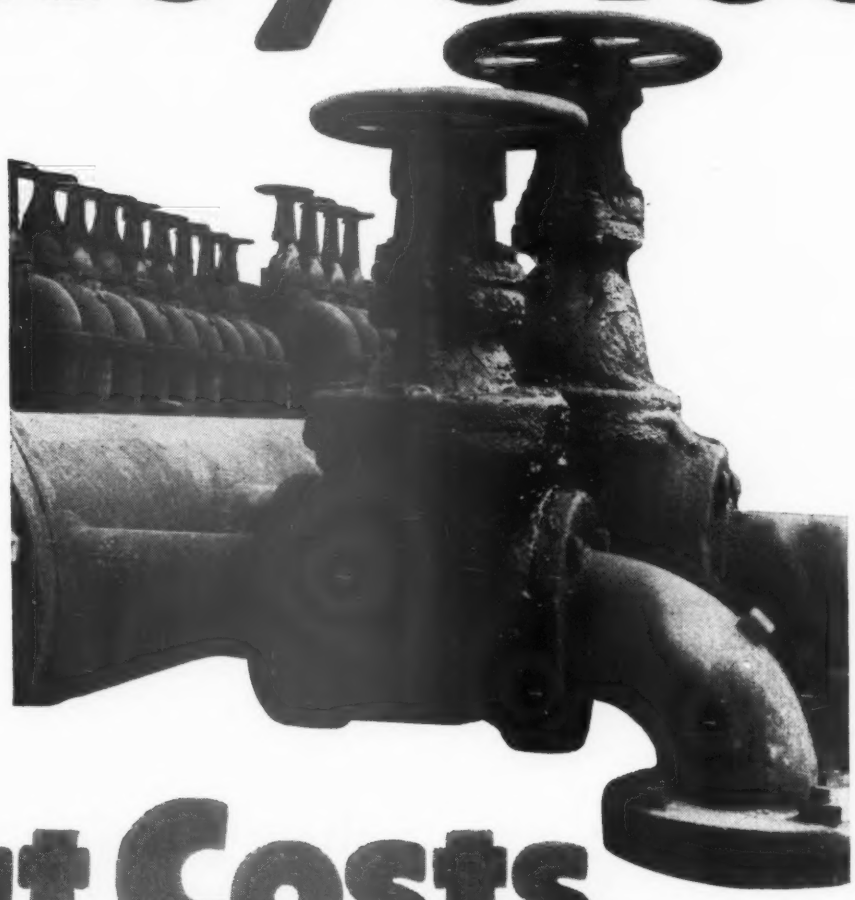


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FIG. 2. Six scrapers are attached longitudinally 26 in. apart to each sucker rod that is run in a string at the levels where paraffin deposits are found in tubing.

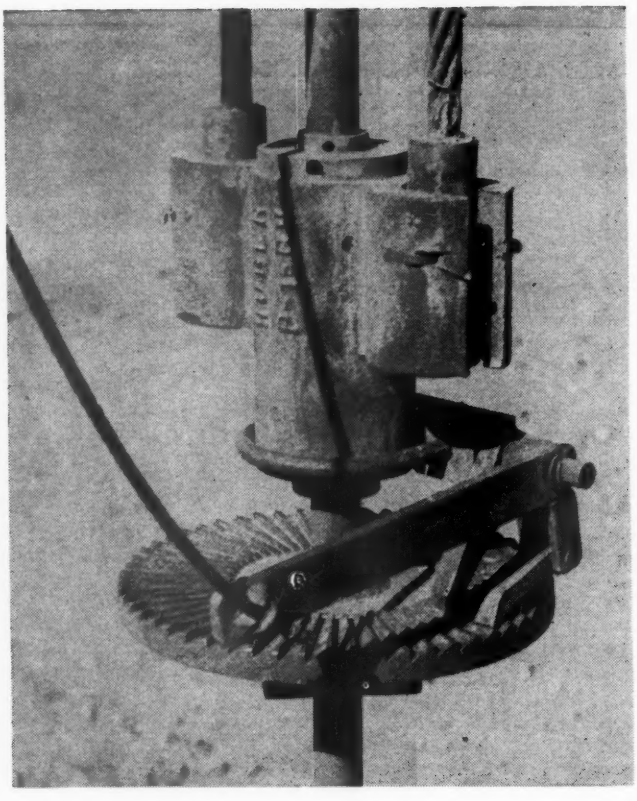

FIG. 3. A ratchet operated rotary hanger turns entire rod string as well is pumped, thus keeping scrapers working against inside wall of tubing in wiping motion.

Scrapers on sucker rods reduce paraffin deposits

By EARL V. GARRETT, J. M. Huber Corporation

THE removal of paraffin deposits from the tubing of pumping wells, especially from those wells nearing depletion, has long been a source of concern to the operator. This concern results not only from costs directly attributable to paraffin, but the many intangible costs such as excessive wear on surface equipment, lost production, and increased power consumption.

EXCLUSIVE

The operators in paraffin areas are aware of these costs, but have had difficulty combatting this situation. The use of scrapers on sucker rods and a rotary polished-rod hanger have effectively reduced these costs.

Most of the large oil companies and many independent oil companies in the Mid-Continent area are now using these scrapers and rotary hangers in various fields and report satisfactory results.

Three wells that give a comparison of costs directly attributable to paraffin before and after the installation of the rod scrapers and rotary hangers are shown in Tables 1 and 2. The Anderson-Prichard Nelson "A" No. 1 well and Gibson "A" No. 1 well are situated in the Wasson field in Yoakum County, Texas, and another oil company's well is situated in the Ft. Stockton field in Pecos County, Texas.

The scraper is made of flat ⅛-in. soft mild steel, 1½-in. in width, and 2 ft long as shown in Fig. 1. Six scrapers are ap-

TABLE 1. Expense due to paraffin in wells in the Wasson field, Yoakum County, Texas.

	Anderson-Prichard Nelson "A" 1		Anderson-Prichard Gibson "A" 1	
	Before paddle installation	After paddle installation	Before paddle installation	After paddle installation
	12 months	12 months	12 months	12 months
Paraffin expense	$ 1347	0	$ 767	0
Oil produced, bbl	9859	9046	9978	8502
Paraffin cost per bbl	$ .137	0	$ .077	0
Expense reduction first year following installation	$ 1347		$ 767	
Installation cost	401		401	
Net savings, first year	$ 946		$ 366	

TABLE 2. Expense due to paraffin in a well in the Fort Stockton field, Pecos County, Texas.

	Before paddle installation	After paddle installation
	12 months	12 months
Paraffin expense	$ 570	0
Oil produced, bbl	9500	9500
Paraffin cost per bbl	$ .06	0
Expense reduction first year following installation	$ 570	
Installation cost	404	
Net savings, first year	$ 166	

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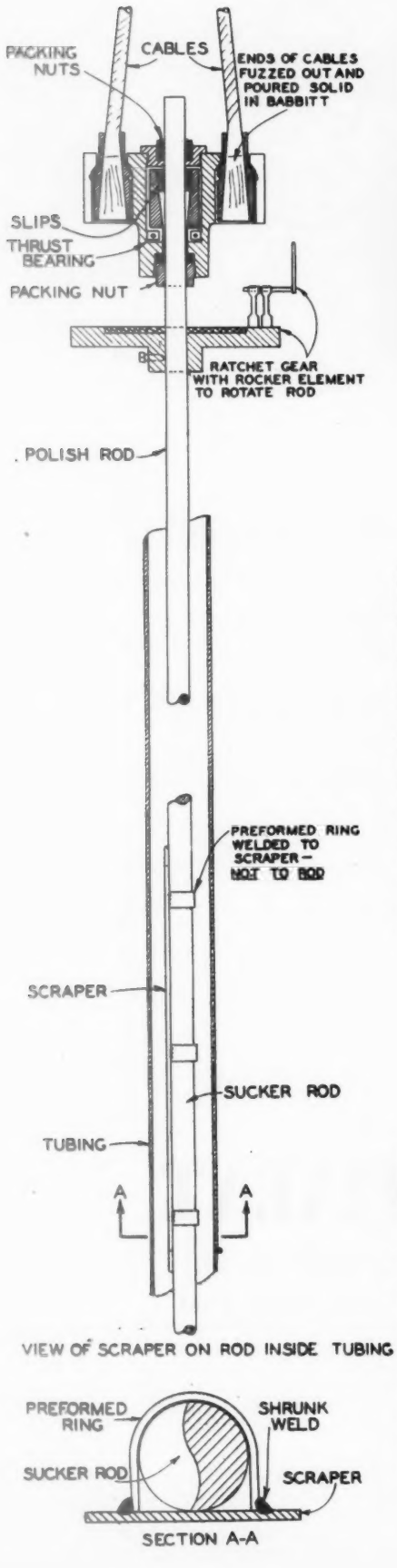
FIG. 1. Diagram of scraper, which is made of flat ⅛-in. steel, 1½-in. by 2 ft.



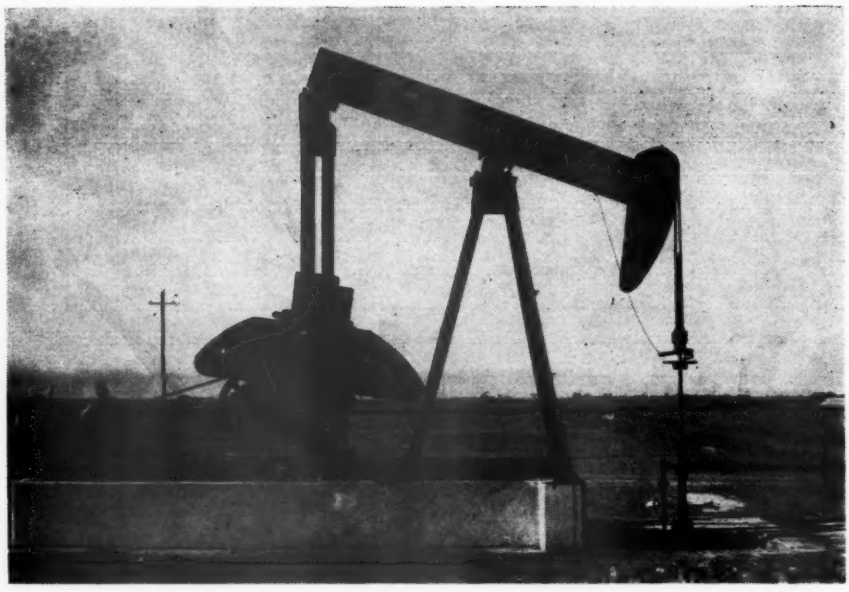


FIG. 4. Wire line from walking beam to rotary hangar ratchet causes rod string to turn a notch with each downstroke.

FIG. 5. Effectiveness of rod scraper installation is revealed by records of a well in West Texas operated by the Anderson-Prichard Company.

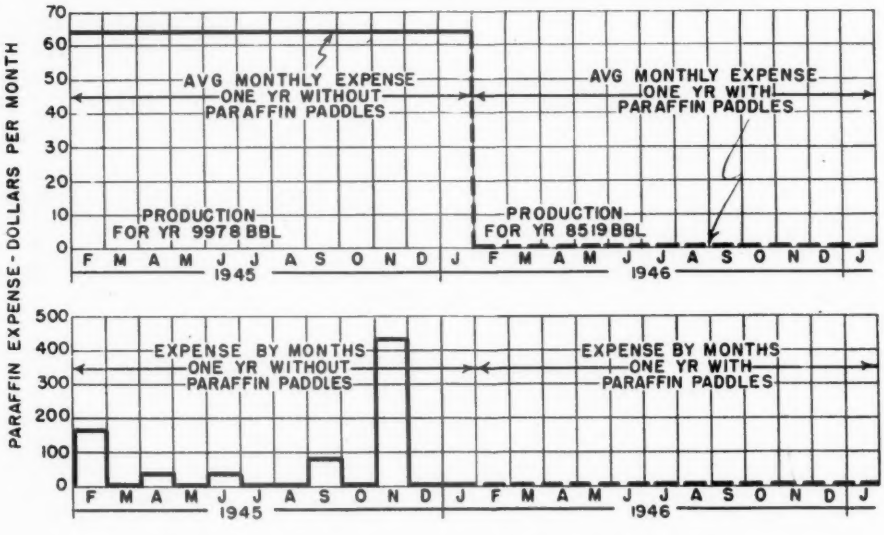
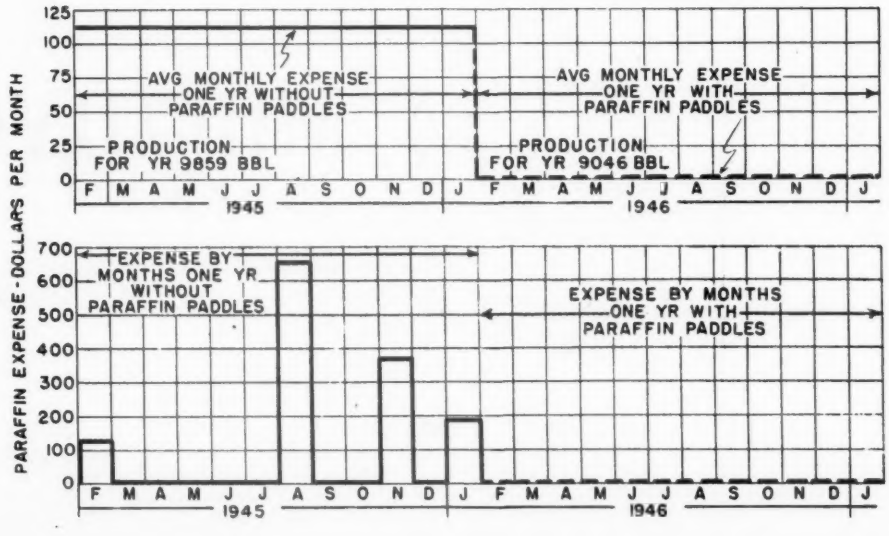

PARAFFIN EXPENSE - DOLLARS PER MONTH
AVG MONTHLY EXPENSE ONE YR WITHOUT PARAFFIN PADDLES
AVG MONTHLY EXPENSE ONE YR WITH PARAFFIN PADDLES
PRODUCTION FOR YR 9978 BBL
PRODUCTION FOR YR 8519 BBL
EXPENSE BY MONTHS ONE YR WITHOUT PARAFFIN PADDLES
EXPENSE BY MONTHS ONE YR WITH PARAFFIN PADDLES
1945
1946

FIG. 6. Paraffin expense records of a well in another West Texas field show effect of rod scraper installation.


PARAFFIN EXPENSE - DOLLARS PER MONTH
AVG MONTHLY EXPENSE ONE YR WITHOUT PARAFFIN PADDLES
AVG MONTHLY EXPENSE ONE YR WITH PARAFFIN PADDLES
PRODUCTION FOR YR 9859 BBL
PRODUCTION FOR YR 9046 BBL
EXPENSE BY MONTHS ONE YR WITHOUT PARAFFIN PADDLES
EXPENSE BY MONTHS ONE YR WITH PARAFFIN PADDLES
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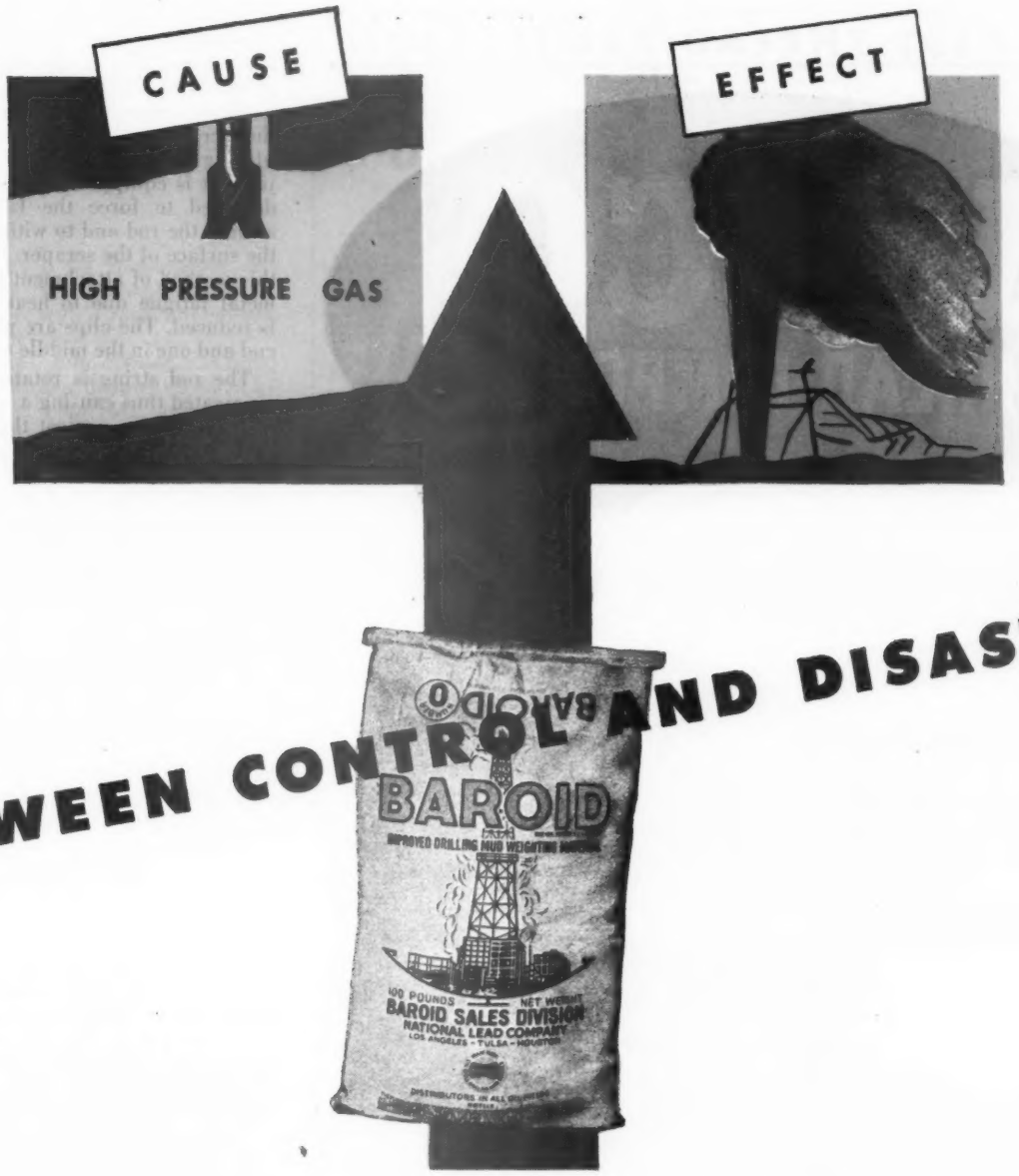
1946



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plied longitudinal to the rod 26 in. apart as shown in Fig. 2. The scrapers are applied to the rods by shrink-welding three U-shaped clips around the rod and to the scraper. This is accomplished by placing the sucker rod in a pneumatic jig that is equipped with pressure arms designed to force the U-shaped clips around the rod and to within 1/32 in. of the surface of the scraper. By employing this method of attachment the danger of metal fatigue due to heat transmission is reduced. The clips are placed at each end and one in the middle of the scraper.

The rod string is rotated as it is reciprocated thus causing a wiping motion of the scrapers against the tubing wall that reduces the deposition of paraffin.

This rotation of the complete rod string is accomplished by a high grade cast-steel rotating hanger (see Fig. 3). The hanger is attached to the head of the unit or jack by means of a wire line

☆ ☆ ☆

Announced by oil-field supply company is a plastic-coated steel pipe resistant to the corrosive conditions often encountered in oil well drilling. During field tests, wells were drilled with a total of more than 60,000 ft of hole.

☆ ☆ ☆

bridle (see Fig. 4). The hanger is applied to the polished rod by case-hardened slips resting on a heavy duty horizontal thrust bearing that supports the entire weight of the rod string. Alignment of the polished rod and lubrication of the bearing are made possible by seals in the top and bottom of the hanger.

The rotating hanger is designed to maintain a safety factor of eight to one under the most severe pumping conditions.

A ratchet-toothed turntable is firmly attached directly below the hanger and horizontal to the polished rod. Two levers are used, one to turn the rod string and the other to prevent the rods from backing up. The levers are actuated by a flexible wire cable secured to one end of the actuating lever and at a determinable point on the head of the unit or jack. This causes the rods to be rotated a fraction of a turn with each down stroke of the unit.

The application of the scrapers and rotary hanger is as simple as their construction. Before the installation of the scrapers, the well should be thoroughly surveyed to ascertain the depths of paraffin deposition. To overcome later trouble from any lowering of this depth, an additional 200 ft of scrapers are recommended at the time of initial installation.

Figs. 5 and 6 show the expenses incurred in removing paraffin deposits from the two Anderson-Prichard wells during the year before the scrapers were installed. No expense for removing paraffin was incurred during the following year. ★★★

Geological interpretation of radioactivity well logs*

By J. E. KILKENNY, Chanslor-Canfield Midway Oil Company

RADIOACTIVITY is the spontaneous disintegration of certain elements into other lighter elements with a resultant release of heat and energy.

Radioactivity can be divided into three basic types of atomic disintegration: (1) alpha rays, (2) beta rays, and gamma rays. The alpha rays consist of doubly charged helium atoms discharged from the parent atom. Beta rays consist of nuclear electrons expelled by the parent atom. The gamma ray is an electromagnetic wave given off at the same time as the beta ray. The gamma ray is the most important of the three from the petroleum industry's economic viewpoint.

A few interesting facts about these various rays are as follows:

The alpha rays are emitted with an initial velocity varying from 8,000 to 12,000 mps. They travel in a straight path. Their range is about 7 cm. They produce ionization and chemical reactions. Their bombardment will break down water into H_2 and O_2 and will react upon hydrocarbons to produce higher hydrocarbons with the release of hydrogen. Alpha rays cause polymerization of gaseous unsaturates into liquids and solids. The alpha rays decrease the atomic number of the elements by two, so that the resultant atom is two groups lower in the periodic table.

The beta rays have initial velocities as high as 99 per cent that of light. The loss of the beta particle (nuclear electron) increases the atomic number of the resultant element and changes it to a periodic group one higher than the parent atom. Beta rays can penetrate several millimeters of aluminum.

The gamma rays travel with the speed of light. They have higher frequencies than the hardest X-rays and a shorter wave length (one ten-billionth of an inch). They are very penetrating and can go through five strings of casing.

The discharge of these radioactive rays is accompanied by considerable heat. One gram of radium gives off 137 calories of heat per hour and in its lifetime is capable of producing heat equivalent to the combustion of one-half ton of coal.

● **Radioactive elements.** The radioactive elements consist of (1) uranium, (2) thorium, (3) potassium (isotope K^{40}), and (4) the rare element rubidium. The first two are the most important in radioactive logging. Potassium, although much more plentiful in nature than the first two mentioned elements, gives off such a low percentage of gamma rays in proportion to its total radioactivity that its effect on radioactive logs is very minor. Uranium and thorium are very rare in nature, but are much more radioactive than potassium.

● **Radioactive minerals.** (a) The important uranium minerals are carnotite and uraninite. These are oxides and are usually found in colloidal form. They are commonly deposited in marine organic shales and sometimes in sands such as the Eocene deposits of Utah and Colorado. A high concentration of uraninite and carnotite in a sediment still constitutes a very infinitesimal fraction of the total volume of the sediment.

(b) The important thorium minerals are monazite, orangite, and thorite. The first is very resistant and is found in well-washed littoral sands associated with rutile, ilmenite, and titanite. The other two are colloidal and are found in clays and shales.

(c) The common potassium minerals are the orthoclase feldspars, the micas, glauconite, and phosphatic nodules.

● **Radioactive rocks.** Among the igneous rocks the high radioactive values are found in the acid types, such as leucite and nepheline syenites and acid granites. Conversely, the basic rocks, such as basalt, peridotite, etc., are low in radioactivity.

Among the sedimentary rocks the brown, organic shales stand out with high values. Rhyolitic ashes and bentonites, especially if young in origin, have even higher values. Clean sands have very low values, as do limestones and barren silts and shales.

The reason for the high radioactive value of brown, organic shales has been the subject of much speculation, thought, and research. Apparently organic matter, in itself, is not the contributing factor because coal is very low in radioactivity. The fineness of the grain size, likewise, is no criterion because barren shales do not have high values.

Several theories have been advanced to explain this phenomenon. Russell has advanced the hypothesis that the radioactive material is formed in the shales by precipitation from solution. This theory presupposes that the chemical environment of basins where brown shales are being deposited, that is, isolated arms of the sea where the water is stagnant, the basin deep and the water warm and reducing conditions prevail, is favorable for the precipitation of uranium salts.

Another theory is that the radioactive material is deposited in the formation by secondary percolating waters after the original sediment has been laid down. Good evidence for this theory is the fact that concretions are high in radioactivity.

A third theory is that the radioactive material is deposited in colloidal form along with other clay particles to form the shales and that its affinity for organic matter causes the two to be laid down simultaneously. The supporting fact in this theory is that the two most highly radioactive minerals, carnotite and uraninite, are nearly always in colloidal form. Laboratory tests show that the uranium salts go into colloidal dispersion before the solubility of the product is reached. Colloidal material accelerates its rate of sedimentation as soon as the salt water content of the sea becomes appreciable. This would prevent much deposition of the radioactive colloids in fresh water.

Each of these theories is incomplete and there may be some unconsidered factor that is the key to the answer.

● **Radioactive well logging mechanism.** The measurement of gamma ray intensities is accomplished by means of an ionization chamber about 3 ft long that contains two insulated electrodes. The chamber is filled with inert gas under high pressure. When lowered into the well, bombardment of the gas chamber by gamma rays emitted from the rocks causes ionization of the gas and a resultant flow of electricity between the electrodes. This flow is relayed through a cable to the recording truck where it is recorded on paper.

The neutron curve is obtained through the use of the same instrument mentioned above, but with the addition of a neutron source shielded from the ionization chamber. The neutrons bombard the formation, stimulating radioactivity, which is recorded by the ionization chamber. If the formation contains hydrogen in the form of water or oil, there is a dampening effect so that a dense limestone records a higher value than a porous fluid-bearing sandstone.

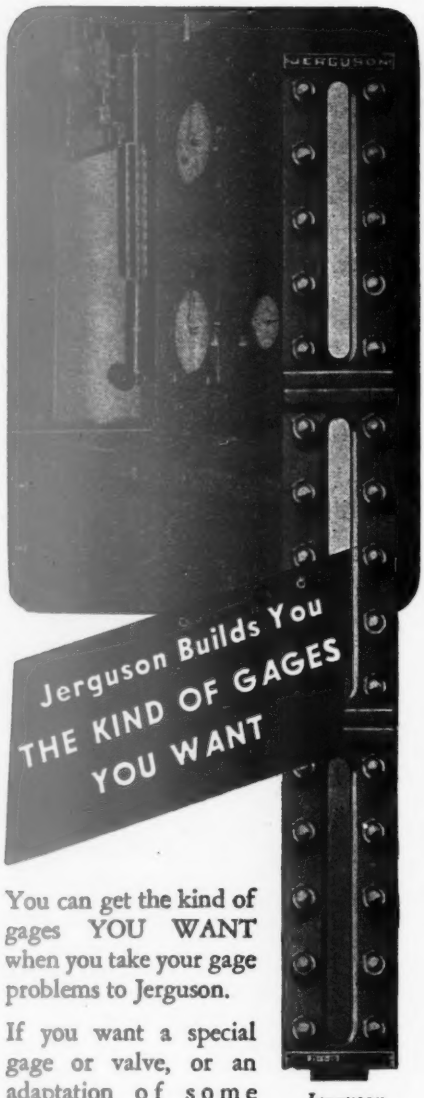
● **Observations from radioactivity log correlations in the San Joaquin Valley.** Bentonite and ash markers show up as long, sharp kicks on the radioactivity log where they may not show at all on electric logs. This is important in sections where continental beds prevail, such as the Zilch formation in the Helm field and the Kern River Series at Edison.

Sporbo and phosphatic nodules are radioactive and show up in the basal Etchegoin beds in the Cymric field logs.

Some of the brown, organic shales in the San Joaquin Valley, such as the Kreyenhagen shale in the Coalinga and Helm fields, do not show high radioactive values. This may be due to the derivation of the shale from Franciscan rocks, composed of basalt and serpentine, on the west side of the Valley.

Radioactive well logs have the special advantage of being able to log cased

*Presented before meeting of Petroleum Division, American Institute of Mining and Metallurgical Engineers, Los Angeles, California, October 24 and 25, 1946.



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wells and may be used to make correlations in old wells drilled before the days of electric logging and coring.

Also, wells with a predominant continental section may be correlated with radioactive logs where other methods are unsuccessful.

Radioactivity well logging has established itself as a valuable tool in finding new production in old fields and as an exploration tool in areas where other logging devices are unsuccessful.

There is room for better and more accurate interpretation of meaning of the kicks on the log. This may be accomplished by more detailed study of the radioactive values in geological surface sections and the actual measurement of the values of different types of sediments in the laboratory. Work of this type has been done in the Mid-Continent area by Well Surveys, Inc., but as far as known, very little has been done here in California.

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Facts to know about selection of bearings

By W. F. SCHAPHORST

Every reader will agree that it would be absurd to use ball bearings on *every* bearing simply because ball bearings run more easily than other bearings. For greatest economy shafts that are used only occasionally should usually be run in plain bearings.

On the other hand, if the power is turned on frequently, even though not continuously, and if electric motors are used for driving, ball or roller bearings may be preferable to plain bearings because the starting friction of plain bearings is considerably higher than is the starting friction of ball or roller types. Besides, the starting friction of roller and ball bearings is not much greater than the running friction. Hence the smaller motors of today are usually equipped with bearings of the anti-friction type.

Where plain bearings can be kept in good condition at all times the cost of the frictional loss as compared with that of ball or roller bearings is often a very small item and may as well be neglected. For example, the frictional cost of running the main bearings of an engine, generator, motor, turbine, pump, and similar large units is ordinarily small compared with the cost of the total power involved, whereas the difference in cost between ball bearings and plain bearings may be high. Under such circumstances, therefore, plain bearings may be more economical even though slightly less efficient. The interest on the difference in cost may be insufficient to cover the difference in losses between the two types of bearings.

Where lubrication may be comparatively more difficult, as on line shafting, and where as a result the difference in friction may be considerable and hence the cost of power considerably less with ball or roller bearings, under such circumstances it is advisable to use a low friction type. An important advantage possessed by roller and ball bearings is that they require less lubricant than the plain type and need not be oiled so frequently.

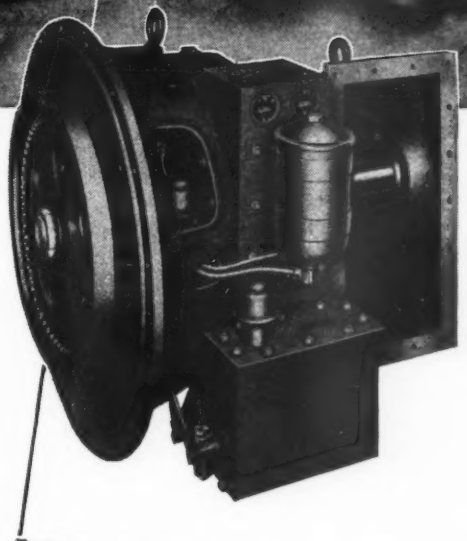
The method of lubricating, also, is a factor. If the value of the installation is such that a modern system of central oiling can be utilized, the plain bearing may prove to be more economical in the end.

On the whole, before deciding one way or the other, one should ask oneself these questions: (A) What will be the total first cost with ball or roller bearings? (B) What will be the total first cost with plain bearings? (Note: These first costs should include electric motors, generators, shafting, bearings, and everything else affected by the power requirements of roller, ball, or plain bearings.) (C) Subtract (B)) from (A). (D) Decide on a percentage to charge against the difference in cost; 30 per cent is considered reasonable by some engineers, but the percentage should be earned annually by the saving in cost of power. (E) If the required percentage can be saved it will pay to install ball or roller bearings.

The above is said to be particularly true of certain types of roller and ball bearings that provide for continuous lubrication over long periods of time. Important advances have been made in the construction of ball and roller bearings in the matter of sealing the lubricant into the housing, serving the double purpose of keeping dust and dirt out and keeping the lubricant in. The maintenance cost of anti-friction bearings of this type is greatly reduced both because of the smaller amount of labor involved and because of the great saving in the amount and the cost of the lubricant itself. In addition the life of the bearing is greatly increased.

In the event that plain bearings are now in use and it is contemplated to replace them with the ball or roller type, the cost of labor in making the change must of course be included in the total first cost. ★ ★ ★

MATCHING BIT SPEED TO FORMATION HARDNESS



Twin Disc Hydraulic Torque Converter (Lysholm-Smith type).

A Twin Disc Hydraulic Torque Converter transfers power from a Cummins Diesel to the rotary table on this Ideco Hydro-Rotary Drilling Unit. It is operated by the Phillips Petroleum Co., in the TXL Field near Odessa, Texas.

Matching drill bit speed with the hardness of the rock formation has been simplified in the oil fields by installing Twin Disc Hydraulic Torque Converters between power units and rotary tables. The use of a Twin Disc Hydraulic Torque Converter makes possible precise adjustment of table speed between the high and low limits of the table drive transmission.

There is no rigid connection in a Twin Disc Hydraulic Torque Converter between driving and driven parts. The power is delivered to the rotary table entirely through fluid mass and motion. Shock loads cannot be transmitted back to the engine, nor can torsional vibrations or other irregularities of power flow reach the rotary table and drill bit. Therefore, a perfectly smooth application of power is assured to govern the speed of the table according to the varying formations through which your drilling may pass.

For full information on the Twin Disc Hydraulic Torque Converter, write the Hydraulic Division, Rockford, Illinois, for Bulletin No. 135-B. TWIN DISC CLUTCH COMPANY, Racine, Wisconsin.

SPECIALISTS IN INDUSTRIAL CLUTCHES SINCE 1918

Main office in Findlay, Ohio, 1947.

Ohio Oil's 60th Anniversary

To mark its 60th anniversary The Ohio Oil Company has issued a history of its operations into which is woven the story of the oil industry. O. D. Donnell, president, stated in announcing the issuance of the 48-page volume, "The purpose of this book is two-fold; to record The Ohio Oil Company's progress and to report to the public on the position of the company in community and industry.

"Sixty Years of Progress" is one of those typical American stories of a company that begins quietly and grows steadily to become an important part of a great industry. The Ohio Oil Company was begun almost by chance when a group of independent operators decided to join forces to see if anything could be done about handling an over-production of crude oil in an Ohio oil field. It was incorporated August 1, 1887. Headquarters were in a room over a hardware store in Lima. The company's first office was a house in Findlay, Ohio.

Today the company has expanded from a crude producing unit to include activities in petroleum transportation and refining and marketing. It is operating in practically all oil-producing areas of the United States; it owns long miles of pipe lines, with their big pump stations in producing and marketing areas; it operates the Robinson refinery in Illinois and the Lovell unit in Wyoming, and it markets the "Marathon" gasoline among other products.

The small volume traces the growth of the company in the intermediate stages since some local operators began working out their problems together in the Trenton limestone field in northwestern Ohio to the present integrated organization with its wide-spread properties and modern facilities.

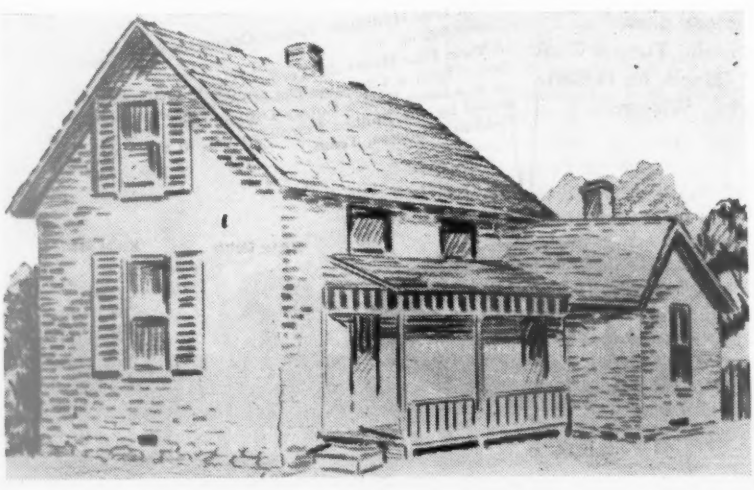
The company grew and changed and expanded. For awhile it was part of the Standard Oil organization that was dissolved in 1911. In 1926 the company opened its biggest oilfield, the Yates field, in Pecos County, Texas, one of the most prolific in the United States.

Of the personnel that led the company through prosperity and depression the one who stands out is J. C. Donnell, father of the present president, who joined the firm in 1889 and was himself president from 1911 to 1927. He helped manage the company during its rapid expansion in the early years and started it on its later development.

The financial status of the organization, its properties, and marketing areas are presented in the book by text, graphs, charts, pictures, and an interesting map in color.

In the foreword, it is stated that "Like other institutions and some individuals, corporations periodically take stock of their origin, the course of their lives and their attainments. Anniversaries are the favorite and perhaps logical occasions for such retrospective appraisal."★ ★ ★

Foster Guyer house, first office in Findlay.



O. D. Donnell, president.

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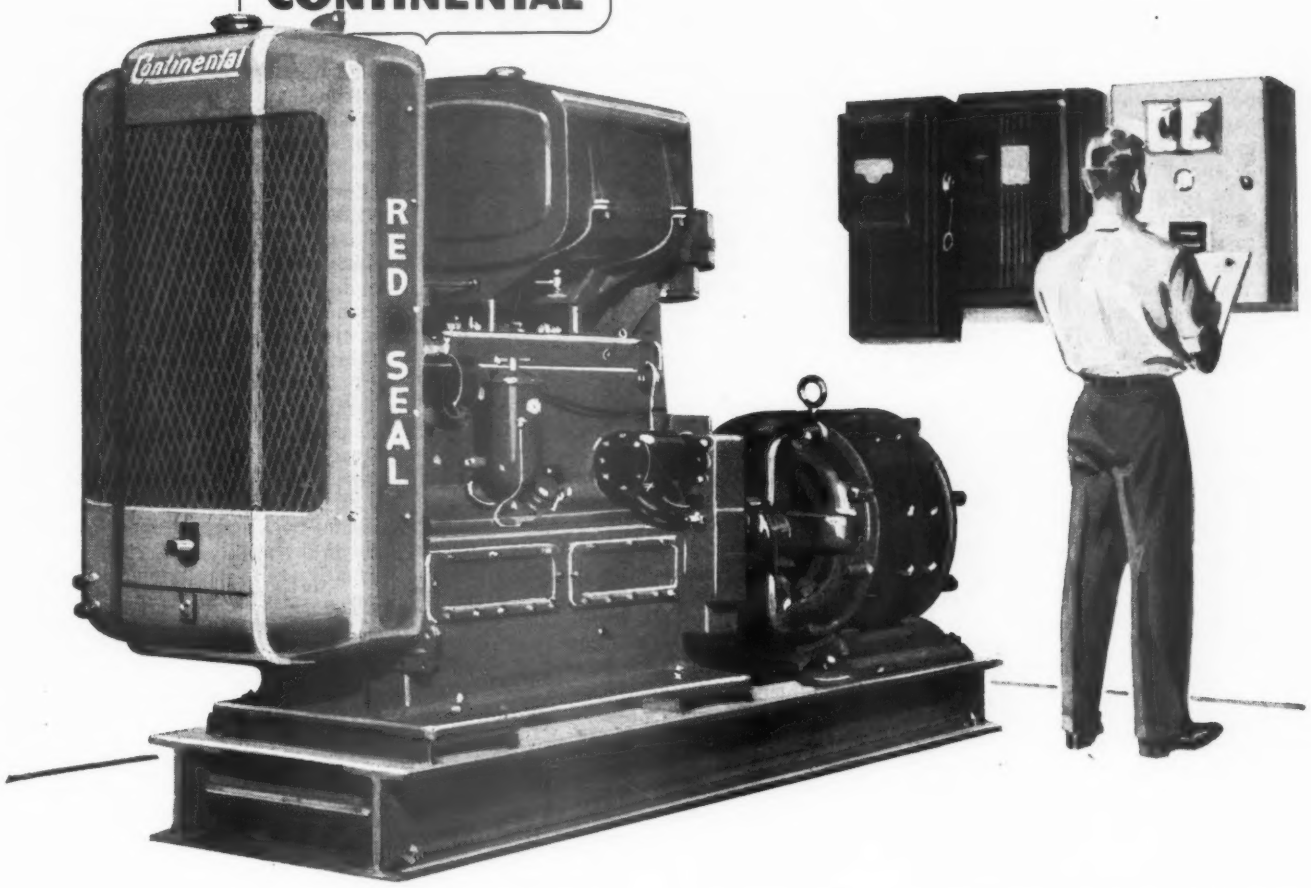

RED SEAL M330 *is a 6-cylinder heavy duty L-head engine, delivering up to 55 shaft horsepower for continuous duty, and 75 horsepower for intermittent duty. It is one of more than 15 engines — ranging from ½ horsepower to 110 horsepower — in the Red Seal oil field line.*

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Red Seal oil field engines give you the maximum in economy and reliability because they are ***built for the job.*** There are no Jacks of all trades in the Continental line. From preliminary engineering right through to the final block-test, each is designed and built to do one thing and do it well. For your tough jobs, where economy and reliability really matter, specify Red Seal Power.

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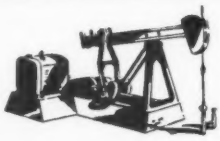
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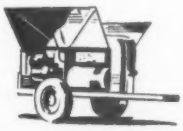
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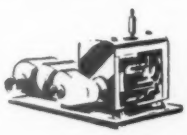
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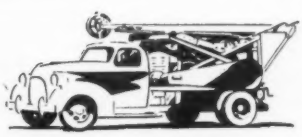

SPUDDERS

TRUCKS

Colorado refinery being enlarged

ENLARGEMENT and modernization now under way at its Denver, Colorado, refinery, will give Continental Oil Company the largest oil refinery in the state of Colorado.

The Denver refinery, five miles from the heart of Denver northeast on U. S. Highway 85, was built in 1930 and operation started during the early part of 1931. The original combination skimming and cracking unit was the most modern in design of units at that time, being built by the M. W. Kellogg Company, and served as a pilot plant for many of the large combination units later built in the country. The original unit was designed to process only 2000 bbl a day of Colorado crudes.

The capacity of the plant was substantially doubled in 1938 as marketing requirements increased and additional crude became available from the Lance Creek field, Wyoming, being transported through the Rocky Mountain Pipe Line.

The present modernization program calls for an expenditure of approximately $4,000,000 to enlarge the plant to process from 8,000 to 10,000 bbl a day of crude oil, the capacity being dependent upon the gravity of the various Colorado and Wyoming crudes anticipated to be available and upon the market requirements for various grades of distillates. This enlargement has necessitated major changes in the existing processing equipment, most of which changes are to be carried out without serious interruption to plant operation.

From one of Continental's refineries recently shut down most of the new crude topping unit equipment is being procured. This equipment will be erected adjacent to the thermal cracking unit, permitting the present operation to continue uninterrupted except for necessary down time to connect the new and existing equipment. Utilization of available refinery equipment will save both time and equipment cost for this part of the plant. The crude topping unit will consist of a two-fractionator tower system for flexibility in producing the maximum quantity of high quality tractor and burner distillates and diesel fuel.

The entire capacity of the existing two-furnace thermal cracking unit will be used for thermal reforming of straight run naphtha from the crude and for thermal cracking of a part of the cycle gas oil from the new catalytic cracking unit. Most of the heat required for distilling gasoline and distillates from the crude will be supplied by exchange heat from the thermal cracking unit oil streams augmented by a new furnace for final heat control on the crude distillation.

A new Thermofor catalytic cracking unit, one of the processes developed during the war for the production of high octane aviation gasoline, the first of such catalytic cracking units to be installed in a refinery in the state of Colorado, will be incorporated in the design of this unit. This catalytic cracking unit will have a reactor charge capacity of 6600 bbl per day, employing Filtrol natural pelleted catalyst in the production of high octane motor gasoline from the cracking of gas oil available from the crude. This catalytic cracking unit normally will be operated with a recycle ratio of one to one but may be operated at a lower recycle ratio, depending upon market requirements for distillate or plant capacity requirements.

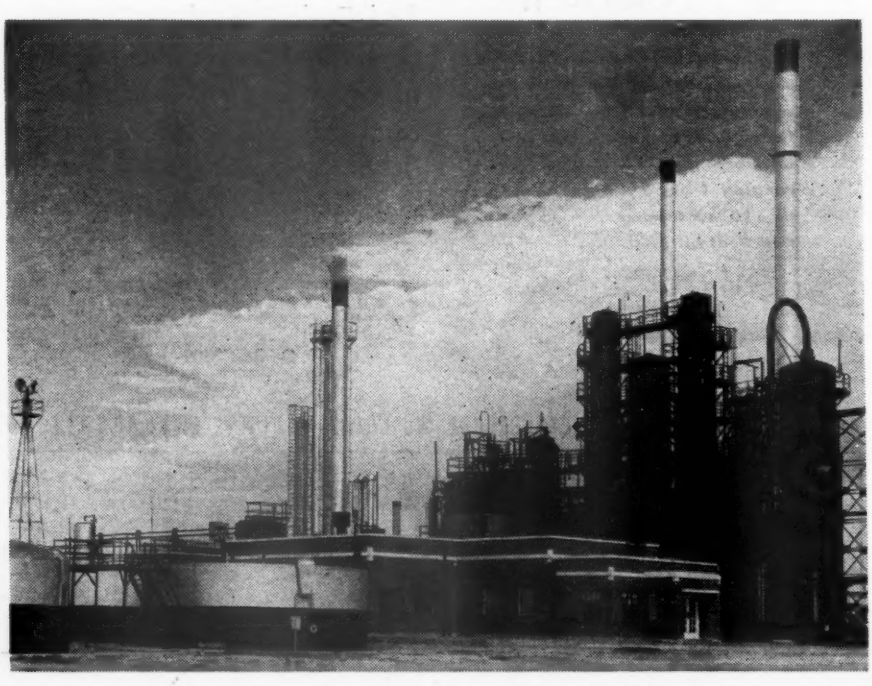
A complete new gas recovery and stabilization unit is being installed to handle the products from the crude topping, thermal reforming and cracking and catalytic cracking units. This section is being designed for high recovery of propylene and heavier hydrocarbon fractions. The propanes and butanes so recovered will be further processed through a Universal Oil Products Company type catalytic polymerization unit for the conversion of the propylene and butylene fractions to additional high octane polymer gasoline while the unconverted saturate propane and excess butane fractions will be separated and sold for liquefied petroleum gas.

The combined flexibility of the process equipment being installed will permit manufacture of a finished blended gasoline of materially improved quality and of higher octane value than was previously possible of attainment from the refinery with conventional crude topping and thermal cracking equipment when processing these Colorado and Wyoming crudes.

This refinery is one of the foremost electrified plants in the country. Substantially the only steam generated and used is that generated as waste heat from the Thermofor catalytic cracking unit, which steam is adequate for process distillation heating, and operating compressors and blowers. Only sufficient boiler capacity is being installed to standby adequately the steam normally generated by the waste heat boilers. The rest of the plant's pumping equipment will be motor driven by purchased electricity supplied through two power lines connected to the plant substation through automatic time delay relay switches so that a power interruption on one line will not interrupt plant operation. These two sources of electric power have given excellent continuity of operation of the plant in the past.

The design of the crude topping and thermal cracking unit and of the battery equipment is being done by Continental's engineers. The design of the rest of the processing equipment and the complete erection of the plant is being done by the Lummus Company of New York. Construction work will begin this summer but completion of the plant is not expected until the fall of 1948 because of slow delivery of certain items of equipment. ★★★

Partial view of Continental's Denver refinery



Spectrochemical sample logging of limestones*

L. L. SLOSS† and S. R. B. COOKE‡

● **Abstract.** Visual examination and insoluble-residue analysis have not yielded uniformly satisfactory data for detailed differentiation and correlation of thick and unbroken sequences of carbonate rocks. The method here presented is an attempt to utilize quantitative spectrographic analysis for this purpose.

An external standard method that gave results reproducible within inherent sample error was used. Ca, Mg, Sr, Ba, Al, Ti, Fe, and Si were present in all samples, and Mn and V in some. For practical reasons, S, P, Na, and K, undoubtedly present, could not be determined. The most useful elements appear to be Mg, Fe, Al, and Sr. When analyses of both surface samples and well cuttings are plotted against stratigraphic interval or well depth, the curves may be interpreted in terms of stratigraphic correlation and differentiation.

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†Formerly, Department of Geology, Montana School of Mines. now Department of Geology, Northwestern University Evanston, Illinois.

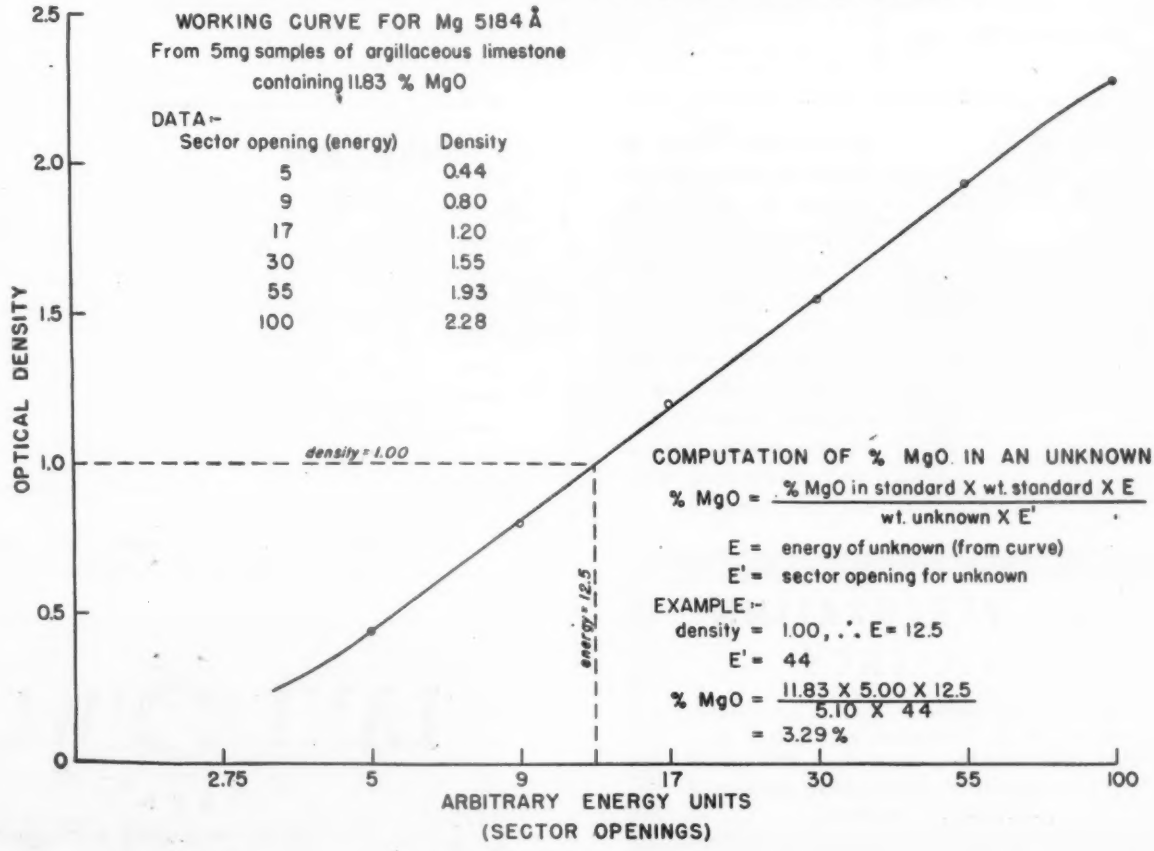
‡Formerly Department of Mineral Dressing, Montana School of Mines; now Department of Mineral Dressing, School of Mines, University of Minnesota, Minneapolis, Minnesota.

Standardization of the method is easy and the results are not dependent on the personal equation. Apart from initial expenditure for equipment, costs and time-consumption should be less than those required for foraminiferal and insoluble-residue analysis.

● **Introduction.** In many areas where carbonate rocks form important parts of the stratigraphic sequence, stratigraphers have experienced varying degrees of difficulty in differentiating and correlating limestones and dolomite units in both surface and subsurface work. Visual examination of samples under the binocular microscope is seldom satisfactory for the recognition of any but the major stratigraphic divisions; and, because of the lack of any standardization of the terminology applied to carbonate rocks, it is often nearly impossible for one worker to interpret a log prepared by another. The addition of tests for dolomite to routine microscopic sample study merely adds another qualitative measure, the sensitivity of which is subject to considerable influence by grain size and surface texture, while the recording of data varies with vagaries of the human equation.

In certain areas, and with certain parts of the stratigraphic section, notably the early Paleozoic rocks of parts of the Mid-Continent province, insoluble residues yield a remarkable amount of stratigraphic data and correlations may be carried over broad distances. Elsewhere within the writers' experience, notably the Mississippian of Montana and Alberta, insoluble residue studies have not produced data which permit the splitting of thick carbonate sequences into small useful units; or if such units appear to be present in one set of samples they can not with any certainty be correlated with other sample suites. This failing is probably due in part to a low density of control points over much of the area, but this is not the whole answer. In most residues from Montana limestone of Meramec age, for instance, the chief constituents are chert, silt, and anhydrite, with nearly complete absence of quartz grains, accessory minerals, or other distinctive items. The chert is irregular in distribution and subject to sampling error. The amount of silt preserved in the residues depends on the amount decanted while washing; or, if it is all to be preserved, a tedious and

FIG. 1. Example showing utilization of working curve for a magnesium line.



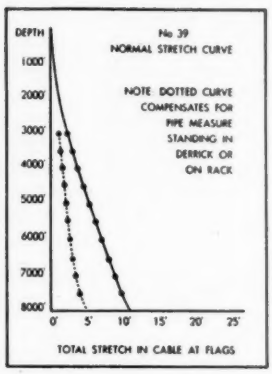
*97% PERFORATING EFFICIENCY

A survey by the U.S. Coast and Geodetic Survey is considered to be the standard for surface measurements over large areas. In base line measurements, every known variable, such as temperature, pull on tape and elevation, is taken into consideration in the calculations.

LANE-WELLS USES THIS 3-WAY CHECK SYSTEM TO ASSURE ACCURATE GUN PERFORATION

STRETCH CURVE

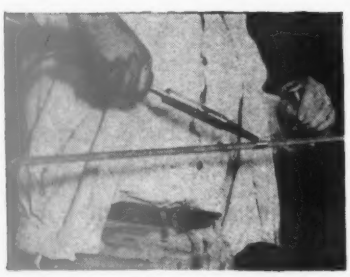
Each cable is calibrated individually using various weights. Cable stretch with depth and loading is charted to enable the operator to adjust for predetermined stretch and check measurement accuracy.



MEASURING SHEAVE

The adjustable sheave wheel permits quick and progressive compensation for variations due to wear in both cable and sheave rim. This exclusive feature assures continuous accuracy of the measure system.

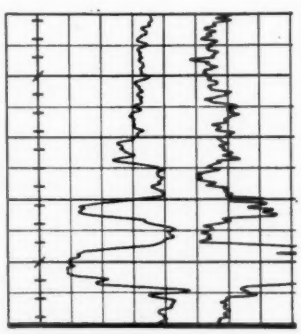
FLAG SYSTEM



Calibration Flags or fixed markers are attached to the cable at regular intervals. Variation in the distances between markers due to instrument weight and buoyancy of fluid is checked against the sheave measurement and necessary corrections applied.

COLLAR LOG

The position of the gun in relation to formations is established by the Collar Log. Measurement accuracy within a matter of inches is possible between collars.



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time-consuming laboratory procedure must be followed. Anhydrite is unusable for surface to subsurface correlations, and in most cases, is as easily detected in the undigested sample.

Having encountered these difficulties, the writers wondered whether the most valuable and diagnostic part of the sample may not be thrown away with the spent acid. With this in mind, qualitative spectrochemical analyses of limestone samples were made seeking trace elements which might prove to be confined to a relatively limited stratigraphic range. Unfortunately, the results of this qualitative investigation were a triumph for the theory of uniformitarianism. All the limestones investigated appeared to be constituted of very nearly the same materials. Among the elements encountered in nearly all samples were calcium, magnesium, strontium, barium, aluminum, titanium, iron, and silicon, with, in some samples, manganese, and vanadium. Sodium, potassium, sulphur, and phosphorus were undoubtedly present in most samples, but because of the technique followed these could not be recognized. It became obvious that any useful data must be gained through quantitative analysis. In the course of analysis of several thousands of samples the procedure explained later in this paper was developed.

Quantitative analyses of both surface and subsurface samples, including cuttings and cores, indicate that the most useful elements are magnesium, iron, strontium, and aluminum, these elements being present in measurable quantities in practically all samples. When the results of these analyses are plotted against well depth or stratigraphic interval the resulting curves or histograms make possible the differentiation of large carbonate sequences into small recognizable units, and these units may be correlated from well to well or from surface section to subsurface.

● **Essentials of spectrochemical method employed.** Most of the satisfactory methods used in quantitative spectrum analysis are applicable to conducting metals only, for the metals form the electrodes in the arc or the spark-gap. Quantitative analysis of non-conducting minerals or of loose aggregations such as mineral powders presents its own problems, the only satisfactory solution consisting of placing the sample in a cavity drilled in a conducting electrode, usually graphite. Following a survey of spectrochemical methods proposed for mineral analysis, and taking into account the limitations of the available equipment, the writers adopted Slavin's "total-energy method"[1] for this investigation.

The basis of quantitative spectrochemical analysis[2] is that the greater the quantity of an element in an excitation source (flame, arc, or spark) the greater is the intensity and hence energy of a given spectrum line emitted by that element, provided that all variable factors such as spectrograph slit-width, optical arrangement, arc gap, and excitation conditions remain constant. These last-mentioned conditions are mechanical or electrical, and reasonable constancy may be assumed.

If the energy emitted by a spectrum line of an element could be measured directly, correlation of quantity with energy could be effected, and analysis by this method should become simple. Until recently, there has been no success in this direction, but within the last few years direct intensity measurement of spectrum lines has been attained.[3]

In the absence of such convenient methods, the photographic emulsion is used to integrate the light energy contained in the spectrum lines, for there is direct correlation between the energy (or intensity) and the photographic blackening, or "density of blackening," produced in the emulsion. The density of blackening is usually measured on a densitometer or microphotometer. Plotting of density of blackening against the logarithm of the corresponding light energy gives what is known as a "characteristic curve" of the photographic emulsion. This is shown in Fig. 1 where the intensity of the 5183.6 Å line of magnesium is plotted against the corresponding optical density of the line on the spectrograms. Six points are plotted, representing six spectrograms; these were obtained by weighing out six 5-milligram samples of a standard[4] lime-magnesia carbonate containing 11.83 per cent MgO and completely violatilizing them in an arc under reproducible and constant conditions. Line intensity was varied by using a rotating sector in front of the spectrograph slit, the least amount of light being admitted when the sector aperture read 5, the most when the scale read 100. As the amount of light admitted is proportional to the scale reading, the amount of energy falling on the photographic emulsion is proportional to the sector opening, and consequently sector openings (on a logarithmic scale) can be plotted directly against optical density.

By Slavin's total-energy method, this curve may be used to determine the magnesia content of any other sample the spectrogram of which has been photographed on the same film or photographic plate. Thus, if a 5-mg sample of a limestone were volatilized under the same arc conditions as the standard samples, with a sector opening of 44, and the measured optical density of the 5183.6 magnesium line were 1.0, then *the arbitrary energy content of the line*, by interpolation from the curve, is seen to be 12.5. On the basic assumption that the line intensity (or energy content) is proportional to the amount of the element, then from the example given the amount of magnesia in the limestone is:

$12.5/44 \times 11.83$ per cent $= 3.36$ per cent MgO.

It is inconvenient to weigh a large number of samples to any given weight, although large variations from the weight of standard taken should not be tolerated. In the present investigation all samples other than the standard were weighed to within 0.20 mg of 5 milligrams, and the exact weight of each sample was recorded. Again, as the line intensity is proportional to the mass of the element present, all other conditions being constant, correction for weight of sample is simple. Thus, in the example given, had the weight of sample been 5.10 milligrams, then the magnesia content would have been:

$5.00/5.10 \times 3.36 = 3.29$ per cent MgO.

The method outlined is simple, but does not give the highest accuracy. As the problem under investigation was considered to be exploratory in nature, high accuracy was not considered essential. No correction was made for "background density," and although Strock[5] states that in at least one case more normal results are obtained by neglecting the background, it seems best to apply a correction as given by Twyman[6], or Brode[7].

Another possible source of error is the effect of extraneous elements on the intensities of the lines of the elements being investigated. This matter has been discussed by Brode[8], who points out that substantial amounts of elements of low ionization potential tend to diminish the line intensities of elements of higher ionization potential. Slavin[9], however, states that he had no difficulty in this respect, and some preliminary experiments by Cooke seem to indicate that

---

[1] M. Slavin, "Quantitative Analysis Based on Spectral Energy," *Indus. and Eng. Chemistry*, Analytical Edition, Vol. 10 (1938), pp. 406-11.

———, "Iron Arc as a Standard Source for Spectrochemical Analysis," *ibid.* Vol. 12 (1940), pp. 131-33.

[2] "Spectrochemical analysis" is a contraction for "spectrographic chemical analysis." As used in this paper, the term refers to chemical analyses utilizing the spectrograph as an analytical tool.

[3] D. H. Rank, R. J. Pfister, and P. D. Coleman, "Photoelectric Detection and Intensity Measurement in Raman Spectra," *Jour. Optical Soc. of America*, Vol. 32, No. 7, July, 1942, pp. 390-96.

M. F. Hasler and H. W. Dietert, "Direct Reading Instrument for Spectrochemical Analysis," *ibid.*, Vol. 34, No. 12, December, 1944, pp. 751-58.

G. H. Dieke and H. M. Crosswhite "Direct Intensity Measurements of Spectrum Lines with Photo-Multiplier Tubes," *ibid.*, Vol. 35, No. 7, July, 1945, pp. 471-80.

George A. Nahstoll and F. R. Bryan "An Application of Multiplier Photo-Tubes to the Spectrochemical Analysis of Magnesium Alloy," *ibid.*, Vol. 35, No. 10, October 1945, pp. 646-50.

[4] Initially synthetic standards were used but these were unsatisfactory due to improper burning characteristics and lack of uniform mixing. The most satisfactory standards were prepared by mixing, in equal proportions. U. S. Bureau of Standards standard samples No. 1a (argillaceous limestone) and No. 88 (dolomite), resulting in a mixture with the following percentages of relevant elements.

	Percentage
SiO_2	7.21
Al_2O_3	2.12
Fe_2O_3	0.86
MgO	11.83
CaO	35.90
SrO	0.06

[5] Lester W. Strock, *Spectrum Analysis with the Carbon Arc Cathode Layer*, pp.. 39-41. Adam Hilger, Ltd., London (1936).

[6] F. Twyman, *The Spectrochemical Analysis of Metals and Alloys*, pp. 98-99. Chemical Publishing Comany, Icn., Brooklyn, New York.

[7] Wallace R. Brode, *Chemical Spectroscopy*, p. 95. John Wiley and Sons, Inc., New York ing Company, Inc., Brooklyn, New York.

[8] *Ibid.*, pp. 98-102.

[9] M. Slavin, "Quantitative Analysis Based on Spectral Energy," *Ind. and Eng. Chemistry*, Vol. 10 (1938), p. 410.

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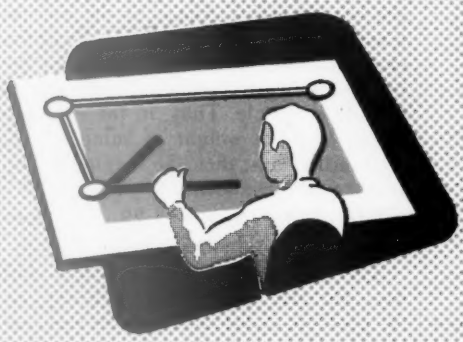

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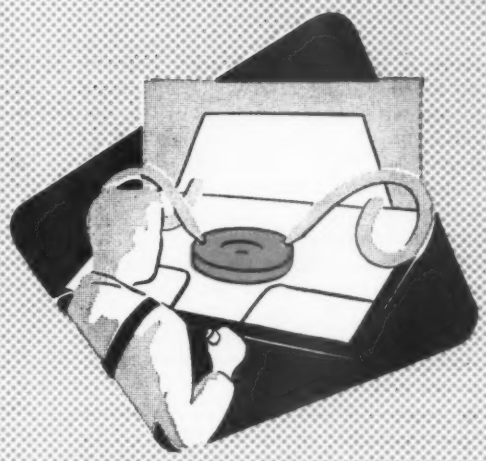

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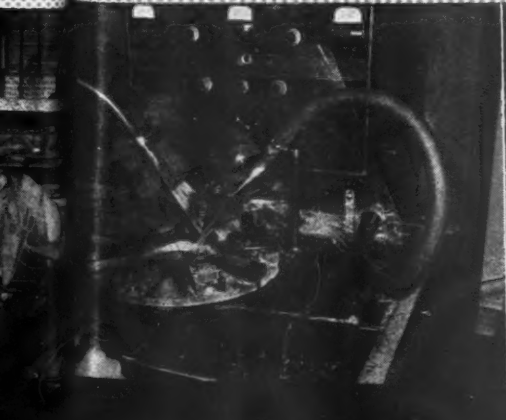

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there is no direct correlation between the ionization potential of a large amount of an extraneous element and the line intensity of an impurity element of higher ionization potential, when the "total energy" method is used. Indeed, with the limetones and dolomites investigated, this effect should not materially vitiate the results, for the ionization potentials of calcium and magnesium are not greatly different. If the effect is a real one, it should be more noticeable with argillaceous and siliceous limestones and dolomites.

● **Apparatus and technique employed. Spectrographic equipment.** The spectograph used in the investigation is a 5-ft Wadsworth type grating spectrograph[10] with an original first-order concave grating. The arc stand is standard Bausch and Lomb equipment, provided with a quartz condensing lens for imaging the arc on either the spectrograph slit or on the collimating mirror. An additional lens serves to project an image of the electrodes and arc on the laboratory wall, permitting close control of gap and arc alignment during exposures.

The spectograph was designed to cover the spectrum from 2,000 to 10,000 Angstrom units, any one setting covering approximately 2,500 Angstrom units. Linear dispersion varies slightly with the wave-length region being photographed, but is always very close to 10.8 Å per mm.

Arc excitation is provided by a motor-generator that delivers direct current at 150 volts through a variable ballast resistor. This, with a variable field resistor, permits accurate control of the impressed voltage to the arc. It is realized that higher arc currents could have been carried, giving shorter exposures, if 220-volt direct current had been used, but unfortunately the necessary apparatus was not available.

● **Preparation of samples.** Where surface samples were involved, these were collected as representative chips from each 10 ft of accurately measured stratigraphic interval. Under certain conditions closer intervals may be required, but the writers have found this distance to be satisfactory for most cases. Samples were crushed with a maul on an easily cleaned iron plate and then were screened in running water, the minus two-mesh, plus eight-mesh material being retained. After drying, representative fragments of the sample were selected for analysis. Fragments containing chert were rejected, as were those with weathered surfaces. The selected material, after further grinding in a porcelain mortar, and final reduction to a powder in an agate mortar, was placed in a labelled glass vial and was ready for analysis.

Subsurface samples, resulting from continuous coring, were handled in a similar manner, whereas carefully picked and washed cuttings went direct to the final grinding and powdering.

● **Sample weighing and electrode loading.** All standard samples used in obtaining the calibration curves weighed 5 mg, plus or minus 0.01 mg. All other samples, as previously mentioned, were weighed to the nearest 0.01 mg within 0.2 mg of 5 mg, and their weights recorded. All samples were weighed on a Roller-Smith torsion balance[11] weighing to 25 mg, this type of balance possessing the three advantages of reproducibility, accuracy when calibrated, and rapidity of operation.

Initially, all samples were weighed out in duplicate and analyzed spectrochemically, but the accordance between duplicates was so good that this practice was discontinued. Single samples are satisfactory, no doubt, for an exploratory program, but it would be preferable to run duplicate samples in routine logging.

The weighed samples were transferred from the balance pan to a small launder made of assay silver, thence through a small, easily cleaned glass funnel to the electrode. Platinum is a more suitable material for the launder than silver.

All electrodes were bored and shaped from ¼-in. Atcheson graphite spectrographic "carbons." These contained so little of the elements being investigated that the additional cost of purification, or of purchase of specially purified graphite electrodes was considered unnecessary.

Some trouble was experienced by the shape initially adopted for the electrodes. After striking the arc the samples heated rapidly, and in a few seconds were above the dissociation temperature of the carbonates. The resulting rapid gas evolution blew portions of the powdered sample from the electrode. This problem was solved by an electrode shaped as shown in Fig 2. The central hole, which carries the sample, was first bored to depth, the electrode being carried in a chuck not unlike that of a small drill-press. The final shaping was effected by running a specially shaped tool over the end of the electrode. The method is rather cumbersome, and an automatic machine could doubtless be devised to accomplish the same result with much less expenditure of labor.

With a 5-mg sample and at 150 volts these electrodes burn very well, with no indication of sample "blowing." The thin-walled graphite cylinder burns sufficiently slowly to permit a slow and orderly decarbonization of the carbonates, so that by the time the gas column of the arc reaches the sample, it has been converted to oxides. With an arc gap of approximately 5 mm, the current remains at 8 amp for 55 to 60 sec. During this interval the spectrum is that of the graphite, that is, carbon and cyanogen bands. At the end of this period the current abruptly jumps to approximately 15 amp as the solids commence to volatilize. Complete volatilization of 5 mg calcium and magnesium carbonate samples may take from 60 to 65 sec under the conditions stated, but is ordinarily complete in 50 sec.

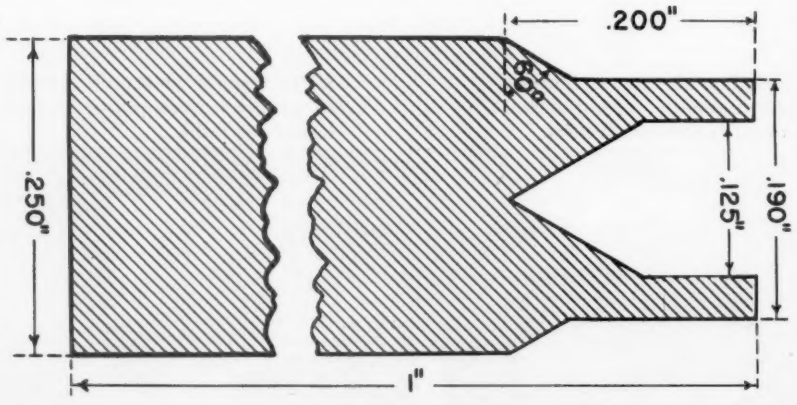
The initial burning away of the graphite cylinder unfortunately contributes to fog and background on the spectrogram, but the advantages gained by even burning of the samples more than compensate for this disadvantage.

● **Photographic processing.** The spectrograph used in this investigation was designed to use 35-mm film, which limited to 12 the number of spectrograms that could be made on any one film. Where many samples required analysis, the number of film-strips requiring processing grew to embarrassing proportions, increasing the difficulties of adequate development. Undoubtedly, a large Littrow quartz spectrograph would shorten the time required per sample by permitting a larger number of spectrograms to be photographed on one large plate. Further, brush development, recommended to eliminate the Eberhardt effect, is certainly easier to use on plates than on films. Reciprocity error can be reduced to a minimum by proper choice

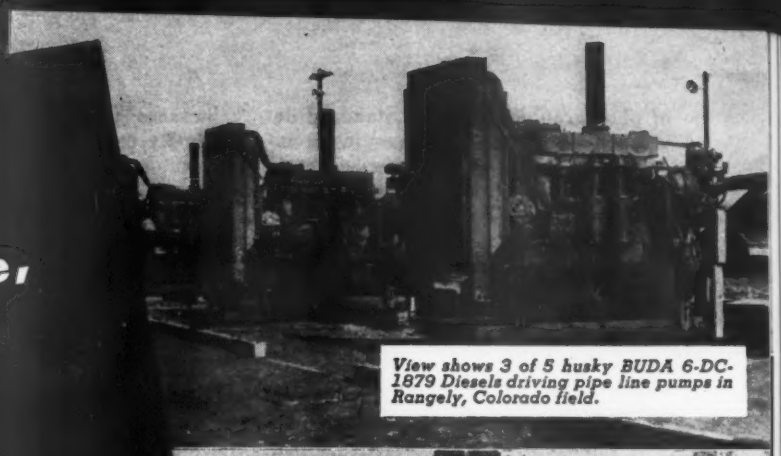
[10]Robert A. Wilson, *The Design and Construction of a Five-Foot Wadsworth Type Grating Spectograph.* A thesis submitted to the Department of Mineral Dressing in partial fullfilment of the requirements for the degree of M. S. in mineral dressing. Montana School of Mines, Butte, Montana, June, 1941.

[11]Roller-Smith Company Bethlehem, Pennsylvania.

FIG. 2. Diagram showing shape of electrode.



Gas, Gasoline, Butane, Propane and Diesel



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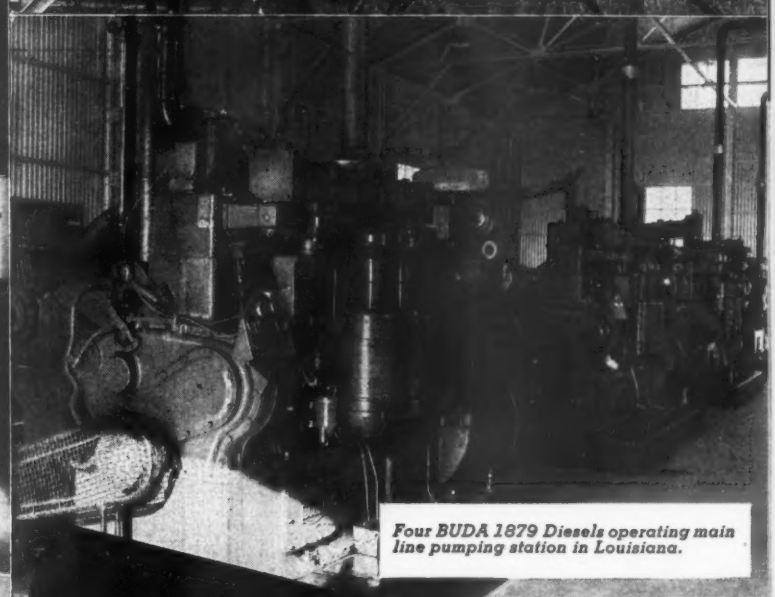

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of photographic emulsion. Standard developers and fixers were used in the investigation, and all films were developed under carefully controlled temperature conditions to a gamma of approximately unity.

● **Density measurements of spectrum lines.** Line densities on the processed films were measured on a Gaertner spectrum microdensitometer.[12] This is a subjective type instrument, requiring a widened line for measurement, with a corresponding loss in resolution and an increase in fogging and background density on the plate or film. With this densitometer minimum line widths were 0.1 mm, or at the linear dispersion employed, approximately 1.1 Angstrom units. Under these circumstances impurity lines had to be chosen that were well separated from other lines that might be partly or completely superimposed on the line under measurement.

Unquestionably, the analytical work could be greatly speeded up, and less eyestrain induced in the worker, by using a photoelectric microphotometer, of which a number of types are available.[13]

● **Costs.** During the course of experimental work on this problem costs per sample analyzed have averaged 30 cents. This figure includes laboratory labor at one dollar per hour for sample and electrode preparation, burning of the sample, development, density measurement, and calculation of percentages of four elements. The figure also includes material such as electrodes, film, and photographic chemicals. Undoubtedly, un-

[12]S. Jacobsohn and W. H. Kliever, "A New Microdensitometer Based on That of Hartmann," *Jour. Optical Soc. America*, Vol. 25, August, 1935, pp. 244-45.

[12]Harry W. Dietert Company, 9930 Roselawn Avenue, Detroit, Michigan.
Adam Hilger, Ltd., 98 Kings Road, Camden Road, London, N. W. 1, England.
General Electric Company, Schenectady, New York.

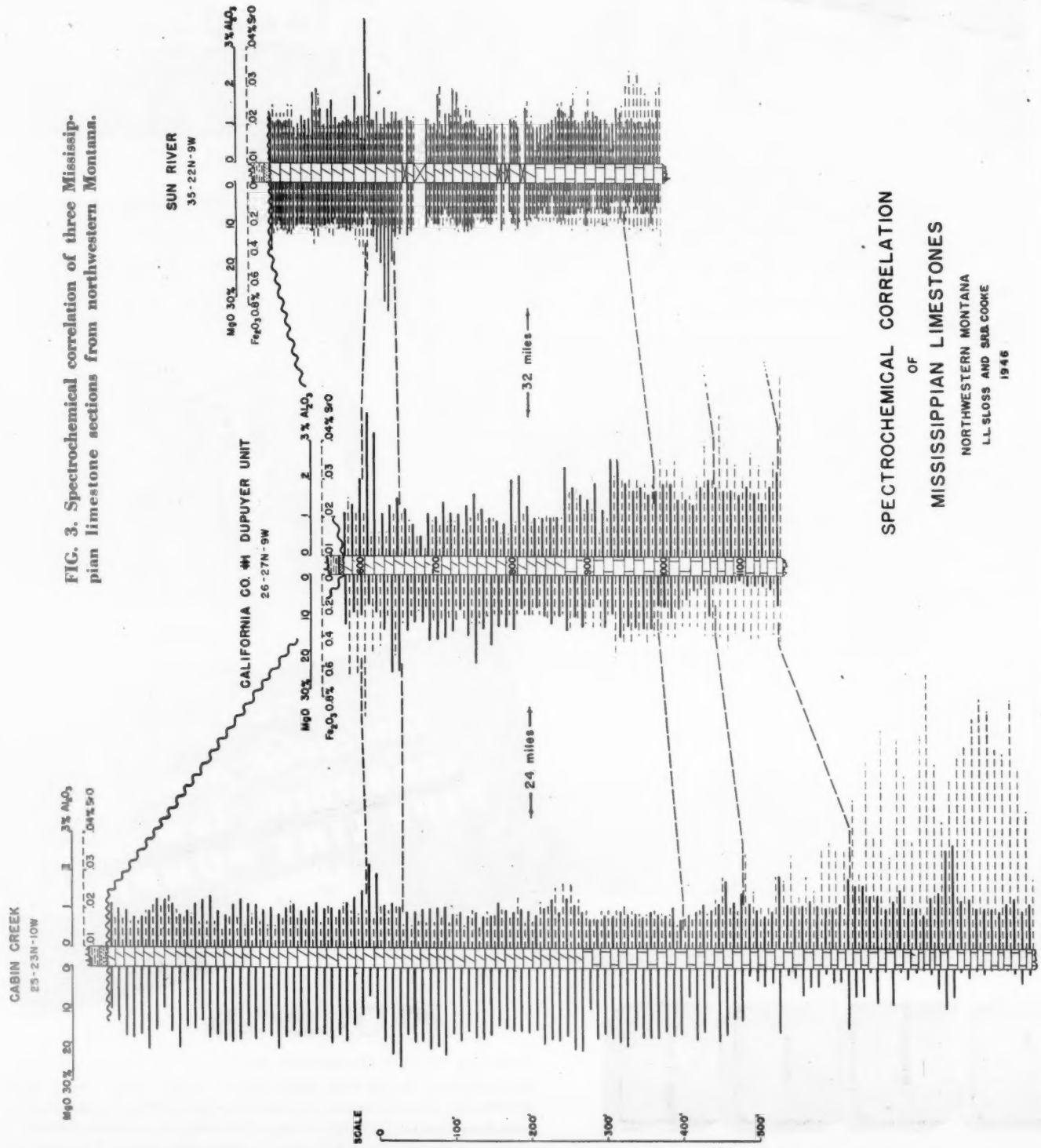

FIG. 3. Spectrochemical correlation of three Mississippian limestone sections from northwestern Montana.

der routine conditions of analysis of large numbers of samples the costs per sample for grinding, a large factor in total cost, could be considerably reduced.

Where such equipment is not available, an original capital expenditure of about $4000 would be required to set up a laboratory for spectrochemical analysis. This figure includes an appropriate spectograph, excitation equipment, densitometer, source of adequate D. C. power, and equipment for the shaping of graphite electrodes.

● **Interpretation of results.** Fig. 3 illustrates the results of a typical series of analyses. There are represented two surface sections and one well, involving Mississippian limestones and dolomites in an area of complex structure in northwestern Montana. In this area pre-Jurassic erosion has cut to varying and difficultly determined depths in the Mississippian. Neither binocular examination of samples nor insoluble residue analysis has successfully delineated zones which may be used as markers in the Mississippian of this area. The plotting of spectrochemical data, however, makes possible the recognition of zones which are indicated by dashed lines on the diagram. The upper of these is characterized by high iron content and low magnesium. Immediately below is a zone of high aluminum content, grading downward into a high magnesium zone. At about 990 ft in The California Company's well a zone is entered that is characterized by decreasing magnesium and increasing strontium; similar zones may be recognized in the two surface sections. Below this zone both the Cabin Creek surface section and The California Company's well encounter a zone of markedly decreased magnesium, followed by a zone very high in strontium percentage. Sampling in the third section was not carried low enough to enter this zone.

Admittedly, the example illustrated does not present spectacularly clear data for correlation, but it should be recognized that the sediments involved were formed under extremely stable conditions without any change in the environment of deposition or major variation in the material deposited. Moreover, the three sections are on three separate thrust blocks and their original positions undoubtedly represented a vastly greater geographic separation than that indicated by the present locations.

Samples resulting from continuous coring of the Paleozoic section in the State Royalty Petroleum Company's State well No. 1 (Sec. 35, T. 4 N., R. 1 E., Harding County, South Dakota) provided an opportunity to apply the spectrochemical method to a sequence of varied lithologies broken by disconformities. Although at the time these samples were run, the technique of analysis had not reached a satisfactory stage of development, the plotted analysis clearly delineated the major stratigraphic breaks and indicated the positions of several potential marker horizons in the thick sequences of Mississippian and Ordovician carbonates and evaporites.

Analysis of other sample suites involving thick anhydrite sections indicates that the presence of evaporites does not offer any difficulties. In fact, there is evidence to indicate that correlation between sections bearing evaporites, and those from which such material has been leached, or in which it was never deposited, may be accomplished.

It is clear from the work done to date that it is far more important to plot the relative differences in the percentages of the various elements through a fairly thick sequence, than it is to determine the absolute percentages in any single sample or small group of samples. It may be possible in some areas and with some parts of the stratigraphic section to identify and correlate units on the basis of a few scattered samples, but in the writers' investigation it has been found necessary to use closely spaced samples, collected over fairly long stratigraphic intervals.

● **Conclusions.** The preliminary work done thus far indicates that the spectrochemical method offers a possibility of solution for some heretofore insoluble problems of correlation. However, much work remains to be done before the method will be applicable over wide areas. It is probable that the four elements that have been proved useful in the investigation reported here will not be useful elsewhere and that other elements must be substituted. Magnesium, for instance, has been a most useful element for correlation in the Paleozoic section of the northern Rockies and adjacent Great Plains, but it would be of very doubtful value in areas of local dolomitization. Moreover, standards that the writers have used for purposes of comparison with unknown samples will undoubtedly need to be revised in other areas and in other parts of the section. Future investigations should also include attempts to apply the method to other sediments than the chemical and organic precipitates to which the present writers' work has largely been confined. ★ ★ ★

Corrected Table for "Corrosion in Distillation Equipment"

We are indebted to Roy E. Kohn of Clayton, Missouri, for calling our attention to certain errors that appeared in Table 1 of the article "Corrosion Tests in Distillation Equipment," by W. Z. Friend and J. F. Mason, Jr., of the International Nickel Company, Inc., which was published in the May, 1947, issue of *The Petroleum Engineer*. For the benefit of readers who may be keeping the article on file for future use we are herewith publishing the corrected table.

TABLE 1. Nominal compositions of metals and alloys used in corrosion tests.

Material	Nickel, per cent	Copper, per cent	Chromium, per cent	Iron, per cent	Molybdenum, per cent	Silicon, per cent	Manganese, per cent	Carbon, per cent	Zinc, per cent	Other, per cent
Monel	67.0	30.0		1.4		0.1	1.0	0.15		
Nickel	99.4	0.1		0.15		0.05	0.2	0.1		
Inconel	78.5	0.2	14.0	6.5		0.25	0.25	0.08		
18-8 stainless steel (type 302)	8–10		17–19	Bal.		0.75 max.	2.0 max.	0.20 max.		
18-8 stainless steel (type 304)	8–10		18–20	Bal.		0.75 max.	2.0 max.	0.08 max.		
18-8 Mo stainless steel (type 316)	10 min.		16 min.	Bal.	2–3	0.75 max.	2.0 max.	0.08 max.		
14-18 per cent Cr steel (type 430)			14–18	Bal.		1.0 max.	1.0 max.	0.12 max.		
10-14 per cent Cr steel (type 410)			10–14	Bal.		0.75 max.	0.60 max.	0.15 max.		
4-6 Cr steel (type 502)			4–6	Bal.	0.45–0.65	0.50 max.	0.5	0.15 max.		
70-30 copper-nickel	30.0	70.0								
Admiralty brass		71.0							28.0	Sn 1.0
Copper		99.9								
Silicon bronze		96.0				3.0	1.0			
Red brass		85.0							15.0	
Yellow brass		65.0							35.0	
Chemical lead										Pb 99.9
Hastelloy A	53.0			22 0	22.0	1.0	2.0			
Hastelloy B	60.0			6.0	32 0	1.0	1.0			
Hastelloy C	51.0		17.0	6.0	19.0	1.0	1.0			W 5.0
Illium G	60.0	4.0	21.0	6.0	6.0	1.0	1.0			W 1.0
Aluminum 2S										Al 99.0 (min.)
Ni-Resist (type 1)	13 5–17.5	5.5–7.5	1.75–2 50	Bal.		1.0–2.5	1.0–1.5	3.0 max.		
Ni-Resist (type 2)	18–22	0.5 max.	1.75–2.50	Bal.		1.0–2.5	0.8–1.5	3.0 max.		
5 per cent Ni steel (SAE 2512)	4.75–5.25			Bal.			0 3–0.6	0.10–0 20		
Mild steel				Bal.			0.3–0.5	0 20 max.		
Cast iron				Bal.		1.5–2.5	0.5–1.0	3.0–3.5		

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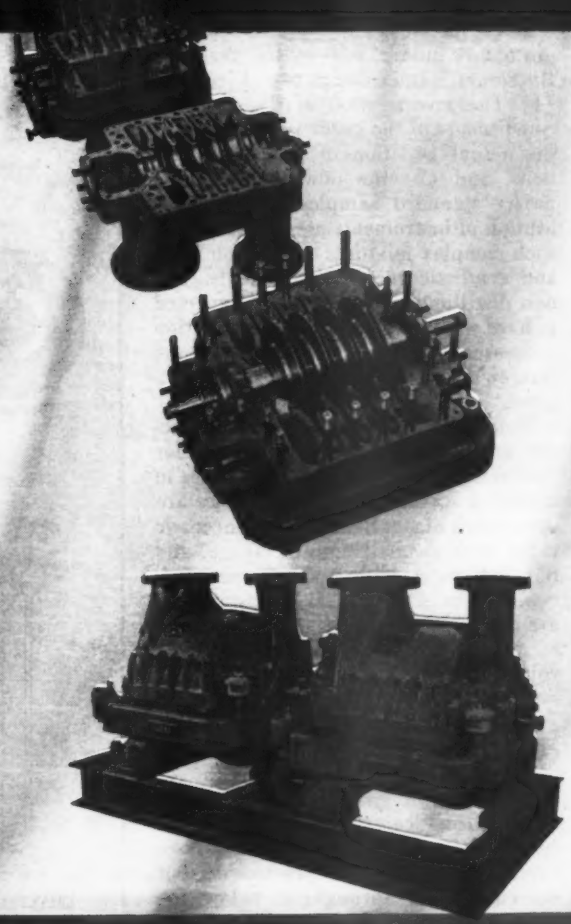

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Rotary concentric-tube distilling column

A NEW rotary concentric-tube distilling column, having a very high efficiency factor for fractional distillation, has been developed at the National Bureau of Standards by Charles B. Willingham, Vincent A. Sedlak, James W. Westhaver, and Frederick D. Rossini, in connection with the cooperative research program on hydrocarbons sponsored jointly by the Bureau and the American Petroleum Institute.

The present-day demand for fuels providing greater efficiency, higher speeds, and more concentrated power, as well as the development of various devices making use of new types of hydrocarbons, has resulted in a transition in the petroleum industry from the manufacture of broad fractions toward the production of narrow fractions and even pure compounds. The experimental program now under way at the National Bureau of Standards has two objectives: (1) The investigation of the chemical constituents of the crude oil based upon the actual isolation of pure hydrocarbons, and (2) the powering of high-purity standard samples for the calibration of instruments used in analyzing such complex mixtures as aviation fuels and synthetic rubber components. The new distilling column, which is expected to have wide application to fractionation processes, will aid materially in the Bureau's hydrocarbon research program.

Numerous devices, based on both theory and experiment, are available for producing high separating efficiencies in distilling columns. Among these are open tubes of small diameter, concentric tubes with a small annular space, and parallel plates with a small space between them. All, however, are limited in use by a relatively low throughput; that is, quantity of material that may be volatilized per hour. According to theory, the efficiency may be improved by decreasing the spacing of the tubes or plates of the column, by decreasing the throughput, or by increasing the rate of diffusion of the gas molecules through the distilling column. Decrease in the spacing (or diameter) has already been carried about as far as practicable, but decreasing the throughput below the present low values is not feasible. Moreover, in a static apparatus, for a given temperature and composition, the rate of diffusion of the gaseous molecules is substantially constant.

Accordingly, the new distilling column was designed to improve separating efficiency by increasing the diffusion rate of the molecules in the gas phase. This is accomplished by forcing the gas

FIG. 1

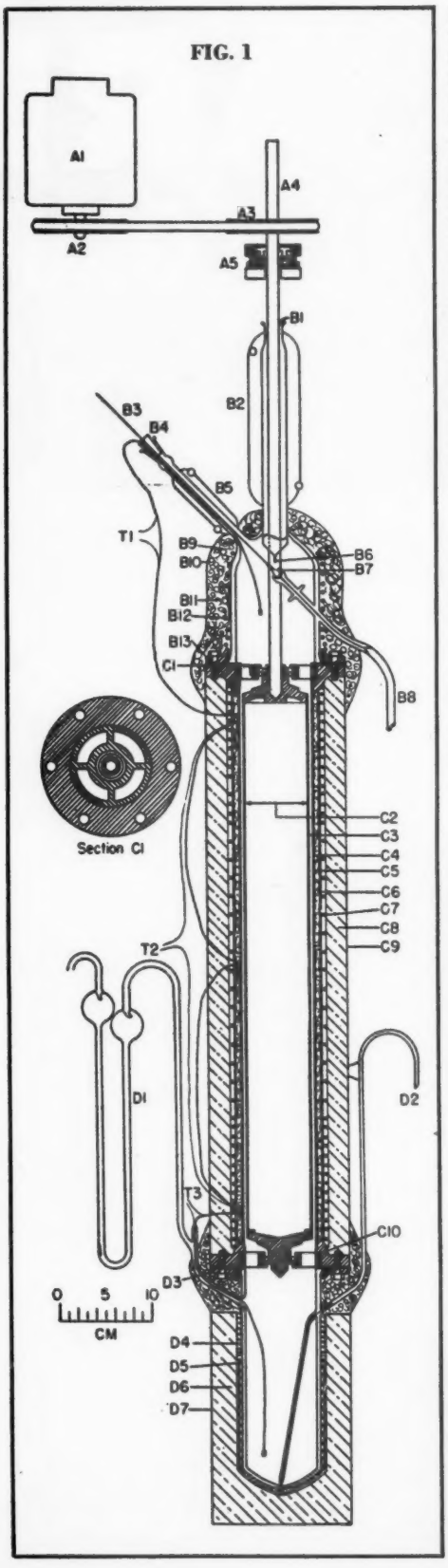

FIG. 1. Schematic diagram of the rotary concentric-tube distilling column recently developed at the National Bureau of Standards. A1, A2, A3, A4, A5 are parts of the motor assembly for rotation of the inner column. The principal parts of the head (B) are: Head condenser (B2) with water jacket, control (B3) for valve (B7) used for sampling liquid reflux in head, side condenser (B5), glass rod (B6) to direct flow of liquid reflux onto valve, outlet (B8) for head sample, thermal insulation (B9), aluminum foil (B10), and nichrome heater unit (B12). The steel rectifying section (C) consists of the cylindrical rotor (C2) concentric with the open tube (C4), the nichrome heating elements (C7), thermal insulation (C8), and aluminum foil (C9). The more important parts of the pot (D) are the butyl carbitol manometer (D1), the tube (D2) for withdrawing samples of material, and the pot heater (D5).

FIG. 2. Removing a test sample of distillate from the new rotary concentric-tube distilling column in the distillation laboratory at the National Bureau of Standards. The rectifying section of this column is an empty annular space 1/24 in. wide, 3 in. in diameter, and 23 in. long, formed by the surface of the cylindrical rotor and the inside surface of the stationary outer wall. The motor-and-pulley system for driving the rotor at speeds up to 4000 rpm and the instruments for the thermometric and electrical power systems are shown.

FIG. 2

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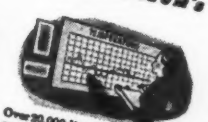

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Prepared for the Oil Industry by the American Petroleum Institute Copr., 1947

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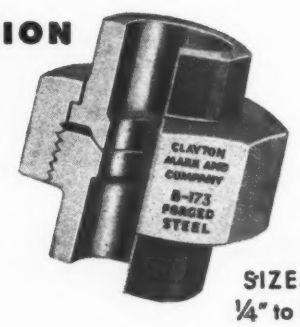

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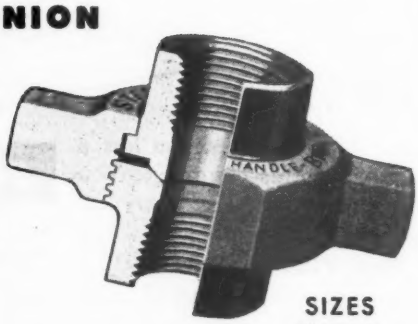

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into turbulence through rotation of the inner closed cylinder in a concentric-tube rectifying section.

The apparatus (Fig. 1) consists of three parts: (1) The Pyrex head, (2) steel rectifying section, and (3) Pyrex pot. All three sections are provided with external heating elements and copper-constantan thermocouples for temperature regulation.

The steel rectifying section of this distilling column is the empty annular space, 0.043 in. (1.09 mm) wide, formed by the inside surface of a stationary outer cylinder and the outside surface of a rotating closed inner cylinder, 2.928 in. (7.44 cm) in outside diameter, and 23.0 in. (58.4 cm) in length. A motor-and-pulley system drives the rotor at speeds up to 4000 rpm. The outer cylinder is enclosed in an asbestos-covered metal heating jacket surrounded by three separate nichrome heating elements for the top, middle, and bottom portions of the jacket, respectively. The heating elements are covered externally with magnesia insulation and a layer of aluminum foil.

The Pyrex glass head consists principally of a water-jacketed condenser directly above and opening into an electrically heated chamber, in which the liquid reflux may be collected and sampled by means of a glass valve. The heated chamber is surrounded by asbestos wool insulation and aluminum foil.

The pot, made of a 3-in. Pyrex pipe, is sealed at one end and provided with a butyl carbitol manometer and a tube for withdrawing samples. Heated externally by a Glas-col special sleeve type heater, it is surrounded by magnesia insulation covered with aluminum foil.

Three thermoelements are provided. One measures the difference between the temperature of the top portion of the rectifying section and the liquid-vapor equilibrium in the head. Another measures the difference between the temperature of the middle portion and mean temperature of the top and bottom portions of the rectifying section. A third is used to determine the difference between the temperature of the bottom of the rectifying section and the temperature of the liquid in the pot.

For high values of throughput—2 to 4 liters of liquid per hr—this distillation column, when operated at 4000 rpm, has an efficiency factor about ten times those previously reported for other rectifying columns. The efficiency factor changes relatively little with throughput at a given speed of rotation, but increases markedly with speed of rotation. This column also has low values of pressure drop per unit throughput, which may be quite advantageous for distillation at low pressure. ★★★

☆ ☆ ☆ ☆

Internal-combustion engines on farms (cars, trucks, airplanes stationary engines) consume 20 to 25 per cent of all petroleum products in the U. S.

Economical alignments for pipe lines

By ALBERT J. GEIGER, *Production Engineer*
Deep Rock Oil Corporation

PEYTON BRYAN'S article "Economical Alignments for Pipe Lines," (*The Petroleum Engineer*, October, 1946, p. 212) was very interesting and the author is to be commended for his attempt to solve this difficult analytical problem. I should like, however, to point out a simple graphical solution that will give the shortest and/or most economical layout of a pipe line connecting three points.

EXCLUSIVE

During August, 1945, while checking the design of a proposed salt water disposal system, I tried to derive a formula that would give the shortest amount of pipe required to connect three or possibly four points. Failing to derive such a formula, even after checking with several other engineers, a graphic solution was attempted.

It was found that if any internal angle of a triangle constructed by connecting the three points by straight lines is 120 deg or greater, the shortest distance connecting the three points would simply be the two sides of the triangle adjacent to the 120 deg or greater angle. If, however, all internal angles of the triangle are less than 120 deg, a point within the triangle can be found, which if connected to the vertices, will give three lines, the sum of which is the shortest distance connecting these three points. It was

FIG. 1

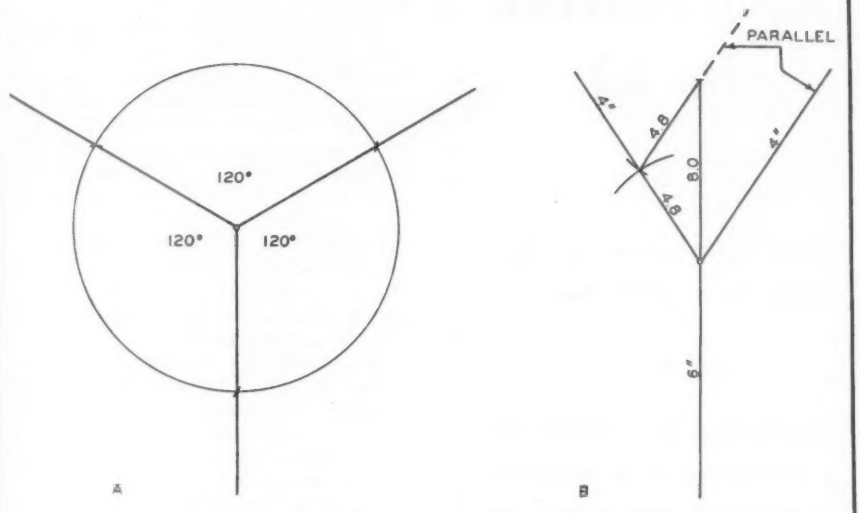
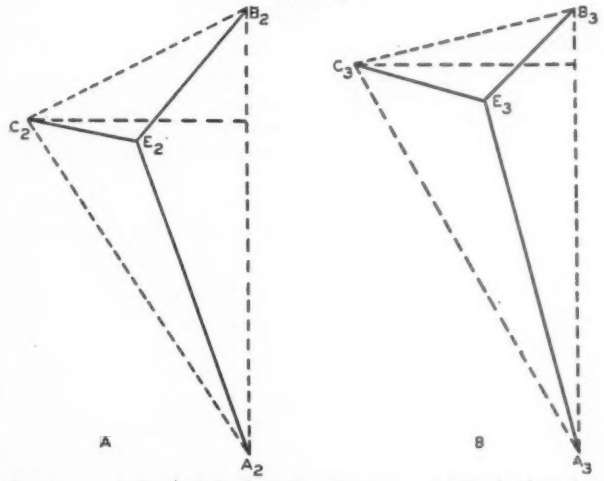


Diagram for locating the shortest distance connecting three points.

Diagram for locating the most economical route of a pipe line connecting three points when two of the branches are to be 4 in. costing $4,800 per mile and one branch 6 in. at $8,000 per mile.

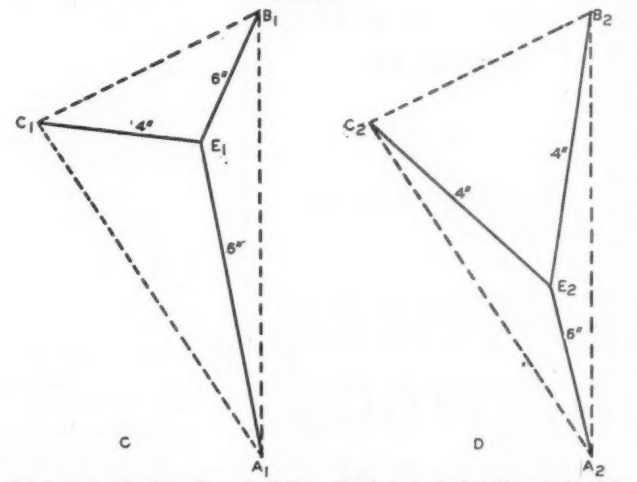
FIG. 2



Total . . $A_2E_2 + C_2E_2 + B_2E_2$
Graphic method 27.75
Bryan method 27.88
Scale 1" = 8 units

Total . . $A_3E_3 + C_3E_3 + B_3E_3$
Graphic method 28.32
Bryan method 28.65

FIG. 4



Total cost of pipe line: $A_1E_1B_1$ 6 in., C_1E_1 4 in.
Graphic method: 7.41 miles 4 in. at $4,800 per mile = $35,568. 20.83 miles of 6 in. at $8,000 per mile = $166,640 Total cost of pipe line = $202,208.
Bryan method: $202,528.
Scale 1" = 8 miles

Total cost of pipe line: A_2E_2 6 in. $C_2E_2B_2$ 4 in.
Graphic method: 23.50 miles 4 in. at $4,800 per mile = $112,800. 7.90 miles of 6 in. at $8,000 per mile = $63,200. Total cost of pipe line = $176,000.
Bryan method: $183,600.

found that the sum of these three lines will be a minimum when they intersect at angles of 120 deg.

An accurate instrument for finding this intermediate point was made by scribing three lines on a sheet of celluloid so that they intersect at angles of 120 deg at a pin hole in the sheet. To find the shortest distance connecting three points the celluloid sheet is placed over the map and positioned so that the three scribed lines pass through the three points. Pencil dot the map through the pin hole, remove the celluloid sheet, draw lines from the pencil dot to the three points, and the shortest route connecting the three points is plotted on the map.

If the three pipe lines differ in size and unit cost, the shortest route will not be the cheapest. The most economical route can be located graphically by drawing a triangle similar to a force diagram (Fig. 1) using the unit cost of the three legs of the pipe line as the length of the three sides of the triangle. With this triangle drawn on tracing paper two sides can be extended to a sufficient length and a parallel to the third side drawn through the intersection of the other two sides giving three lines that extend radially from a common point.

By placing this tracing over the map so that the three lines pass through their respective end points on the map, a pin prick or pencil dot on the map at the point of intersection of the three lines on the tracing will locate the intermediate point for the most economical route.

In instances where the line route of one leg is fixed by terrain, highway, right-of-way, or some other limiting conditions, the shortest and/or most economical point from which to branch to the other two points is determined in the same manner except that the pin hole or point of intersection of the three lines on the instrument is positioned directly over the fixed leg so that two lines pass through their respective points. There are limitations to this application and it is well to check the perpendicular in instances where one branch intersects the fixed route with an included angle of 90 deg or less.

Figs. 2 and 3 illustrate that the graphic method is more accurate and far quicker than the mathematical method outlined by Mr. Bryan.

The shortest distance connecting four points can be plotted in much the same manner using two of the celluloid instruments, one for two points and one for the other two, and positioning them so that two legs of each instrument pass through its two points on the map while the third leg passes through the pin hole of the other instrument. This will give two intermediate points on the map, which when connected together and each to its respective end points will give the shortest connecting distance.

As Mr. Bryan pointed out, these routes cannot always be followed exactly but are useful in selecting the most economical route. Even in laying out lease lines where only short distances are involved, this graphic method of pipe-line layout will often result in substantial savings.

★ ★ ★

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Possibilities for oil and gas in New York*

By E. T. HECK, Quaker State Oil Refining Corporation

● **Introduction.** On March 1, 1946, the writer joined the staff of the New York State Science Service to take charge of oil and gas investigations in the office of the state geologist. One of the first questions that arose was, "What are the possibilities of finding additional oil and gas in New York?" This paper may be considered as a progress report on studies undertaken to answer the above question. The method used in the study has been to check all available literature on the general geology of New York State and to supplement the literature by discussion with a number of geologists who know the state thoroughly. It is not possible to list each individual who has contributed to this study but special mention is due the state paleontologist, Dr. Winifred Goldring, the retired state geologist, C. A. Hartnagel, and assistant state geologist, Dr. John G. Broughton.

As will be described in more detail herein, for the purpose of this discussion, the state has been divided into three major areas: One in which drilling is not to be encouraged, a second area that contains all the known oil and gas fields, and a third area in which there has been almost no drilling but which, from a geological point of view, appears to have all requisite features for oil production.

At the request of the program committee of the Eastern Division of the American Petroleum Institute this paper has been extended to include comments on the entire Appalachian Basin. The comments on areas outside New York are based on the writer's experience and general knowledge, and not on a special study for this paper. It is regretted that time did not permit the preparation of detailed illustrations for areas outside New York.

● **General considerations.** A knowledge of the general divisions of the geologic column, and the relative positions of the various producing sands, is essential to an understanding of the following discussion. Fig. 1 shows a generalized geologic column and indicates the various horizons that have produced oil and gas in New York State. Various names and boundaries shown on Fig. 1 will be referred to in the remainder of the paper without further explanation.

To facilitate this discussion, the state has been divided into three general districts as shown in Fig. 2. These districts or areas will now be considered in turn.

*Presented before Spring Meeting of Eastern District American Petroleum Institute, Division of Production, Pittsburgh, Pennsylvania, June 13-14, 1946, under the title, "Future Possibilities for Oil and Gas in New York State with Comments on Entire Appalachian Basin."

FIG. 1. Generalized geologic section of central and western New York with reference to occurrence of oil and gas.

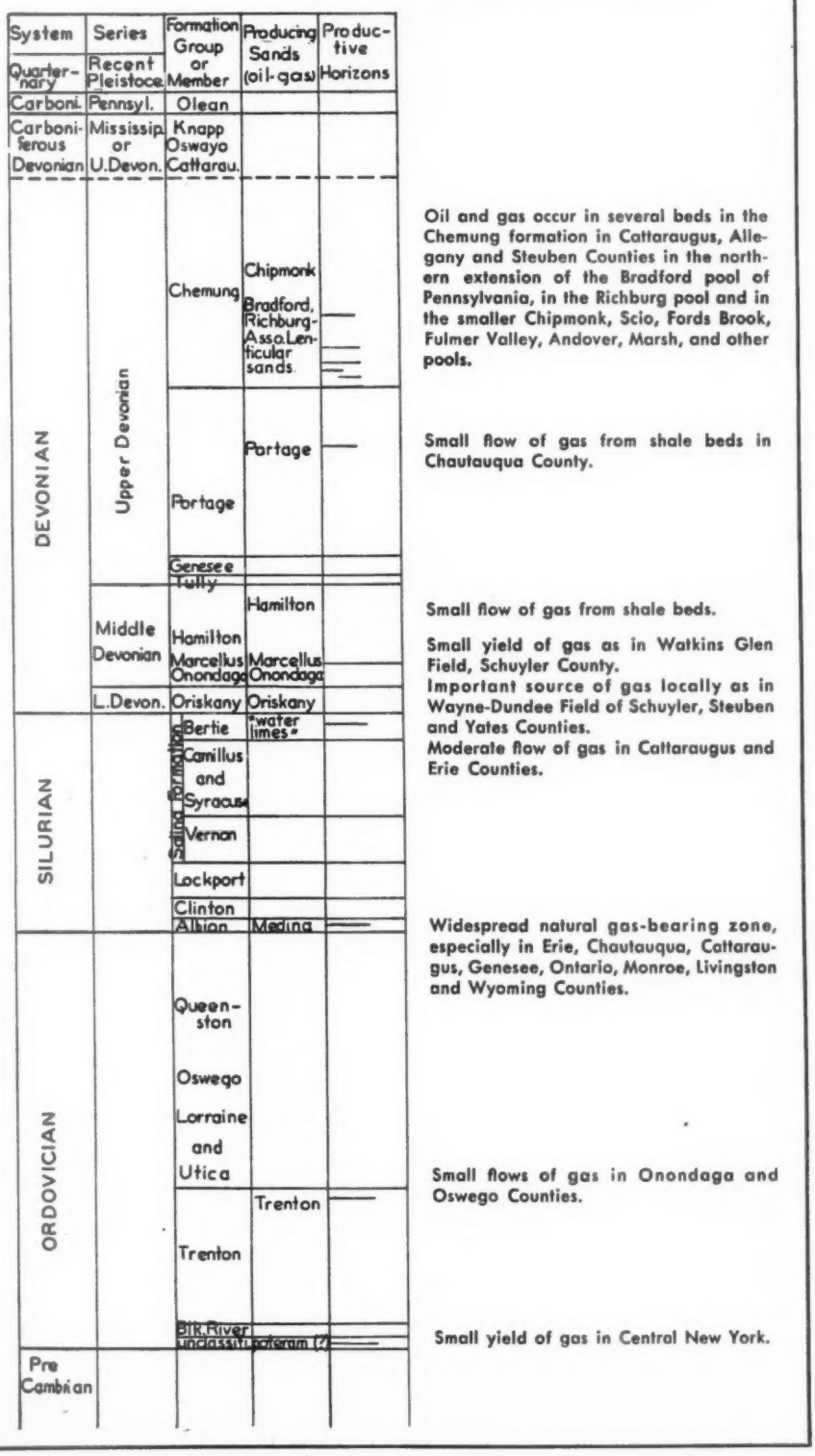
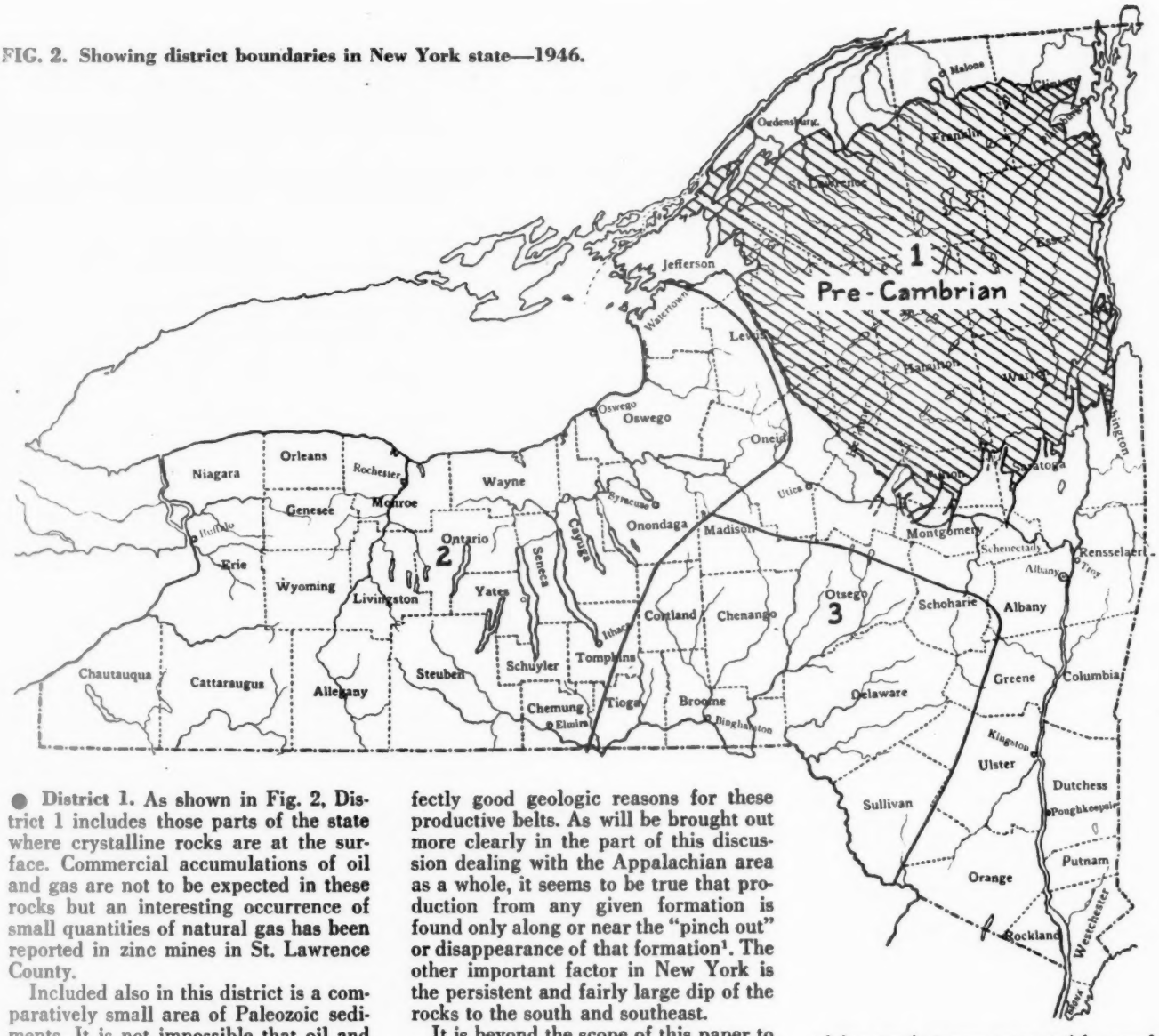


FIG. 2. Showing district boundaries in New York state—1946.



● **District 1.** As shown in Fig. 2, District 1 includes those parts of the state where crystalline rocks are at the surface. Commercial accumulations of oil and gas are not to be expected in these rocks but an interesting occurrence of small quantities of natural gas has been reported in zinc mines in St. Lawrence County.

Included also in this district is a comparatively small area of Paleozoic sediments. It is not impossible that oil and gas accumulations will be found in these sediments. Dr. Rudolf Ruedemann vouches for the occurrence of non-commercial quantities of crude oil in a shallow well in Washington County. In general, however, the Paleozoic sediments in District 1 are too thin or too highly folded and metamorphosed to encourage drilling.

● **District 2.** As mentioned, this district includes all the oil and gas fields of New York State as presently known. Fig. 3 shows this area in more detail. The major producing zones have been indicated by different patterns.

It is readily seen that pools producing from the same formations are not distributed in a haphazard fashion but rather that they are grouped in definite belts. Wells producing from the upper part of the Devonian are largely confined to the southern tier of counties. The Oriskany belt is in the same region but extends somewhat farther south and east. The Medina belt is found near the Great Lakes and the Trenton production is grouped near the eastern end of Lake Ontario.

In New York State there are two perfectly good geologic reasons for these productive belts. As will be brought out more clearly in the part of this discussion dealing with the Appalachian area as a whole, it seems to be true that production from any given formation is found only along or near the "pinch out" or disappearance of that formation[1]. The other important factor in New York is the persistent and fairly large dip of the rocks to the south and southeast.

It is beyond the scope of this paper to consider each of these productive belts in detail. It should be noted, however, that it is only in comparatively recent years that an appreciable number of wells have been drilled in New York to depths of more than 2000 or 3000 ft. It is to be expected, therefore, that additional drilling will widen and extend these productive belts to some extent. On the other hand, it is doubtful whether this additional production will be large.

So far only the *major* known producing zones have been considered in District 2. Referring again to Fig. 1, it is seen that there are numerous other zones that may produce. These zones occur between and below the major zones just discussed, and in the writer's opinion, it is these potentially productive zones that will produce any major quantities of new oil or gas found in District 2. Each of these zones is a problem in itself and all cannot be treated here. Two of the more important zones will be discussed briefly.

The Oswego sandstone of upper Ordovician age is a gray or greenish-gray formation. It is very fine-grained, shaly, and thin in the north and west parts of District 2, but thickens and becomes medium to coarse-grained in the south and east parts of the area. The formation interfingers with the overlying Queenston red beds and also appears to have a facies relationship with the underlying fossiliferous Lorraine beds. The general relationship of the beds is very similar to the Upper Devonian rocks that have been so productive in the Appalachian region. It is true that, to date, this formation has not been known to produce but it is also true that almost no wells have penetrated the formation except where it is thin and shaly. One discouraging feature is that it will require wells 6000 to 9000 ft deep to test this formation where it is in good thickness.

Just above the Pre-Cambrian surface there are a series of sandstones and thin dolomites that have been drilled into in only a few wells. At the outcrop this zone is thin and has loosely been referred to as the Potsdam sandstone. In Wyoming County this zone of sandstones and dolomites has a thickness in excess of 800 ft. Some of the sandstone layers are

[1]Facies changes within the same formation will control the location of petroleum accumulations in much the same manner as "pinch outs."

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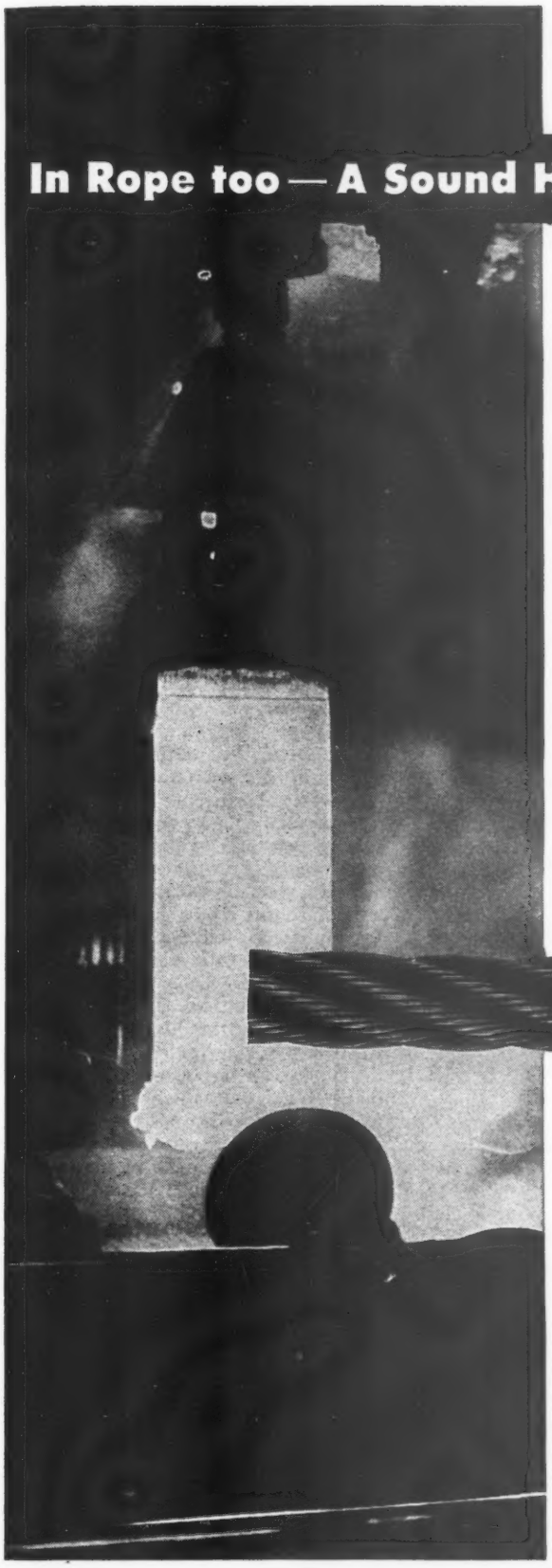

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FIG. 3. New York state gas and oil fields. *(After C. A. Hartnagel.)*

made up of well sorted rounded medium-grained sand. Nearly every well that has penetrated this zone has found at least one permeable streak as shown by the production of salt water. At the writer's request a sample of water from a well drilled to this zone in Cayuga County was analyzed by Homer Hoskins of the West Virginia Geological Survey. The analysis showed 750 ppm of barium. In an earlier paper the writer[2] has called attention to the fact that in West Virginia the brines associated with oil and gas commonly show a high barium content. As these sandstones are water-bearing they should be tested *on structure*. Gas shows have been reported from this zone but, to date, it has not been commercially productive in New York State. Rocks of the same age are important producers in recently discovered fields in the mid-west.

Any well testing the Potsdam zone should continue drilling until it is certain that the crystalline rocks have been reached. Just above the crystallines there is frequently a zone of "granite wash." The presence of this zone of granite wash has not always been recognized and the great Texas Panhandle field alone is sufficient reason for testing such a zone whenever it can be done without too much additional expense.

● **District 3.** To the east of District 2 is a large area in which there has been almost no drilling. The surface rocks are Devonian in age and in general appearance and structural attitude they are similar to the Devonian rocks in District 2.

The absence of test wells in District 3 is indeed puzzling. Inquiries have brought forth only two possible reasons: (a) The district has been considered to be in the high carbon ratio area and therefore condemned by David White's carbon-ratio theory; (b) the lack of pipe lines crossing the district would make it difficult to market any oil or gas found. In the writer's opinion neither of these two reasons should prevent future prospecting in District 3.

The area is due north of the Anthracite basin of Pennsylvania but, because no coal has been found in the Devonian surface rocks, it can be argued that the true carbon-ratio of the area cannot be determined. The writer prefers the view, however, that the carbon-ratio theory is not valid in its type area and should not be applied in judging District 3. The writer[3] has recently emphasized that if the carbon-ratio theory is valid it *must* apply to the vertical succession of beds as well as in the horizontal plane. Reeves[4] has shown that when the vertical change in carbon ratio is considered there is no noticeable relationship between the carbon ratio lines and the occurrence or non-occurrence of oil in West Virginia. It should be remembered that David White cited West Virginia as the area in which the carbon-ratio theory is so clearly demonstrated.

The lack of pipe lines should not prevent prospecting in District 3. In recent

[2] "Barium in Appalachian Salt Brines," E. T. Heck, *AAPG Bulletin*, Vol. 24 (1940) pp. 486-493.

[3] "Regional Metamorphism of Coal in Southeastern West Virginia," E. T. Hack, *AAPG Bulletin*, Vol. 27 (1943) pp. 1194-1227.

[4] "The Carbon-Ratio Theory," Frank Reeves, *AAPG Bulletin*, Vol. 12 (1928), pp. 795-823.

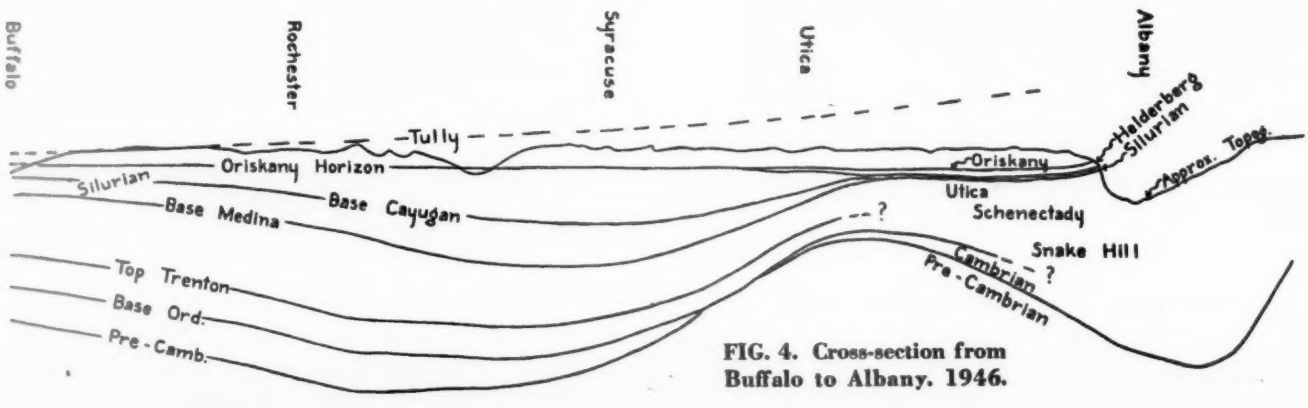

FIG. 4. Cross-section from Buffalo to Albany. 1946.

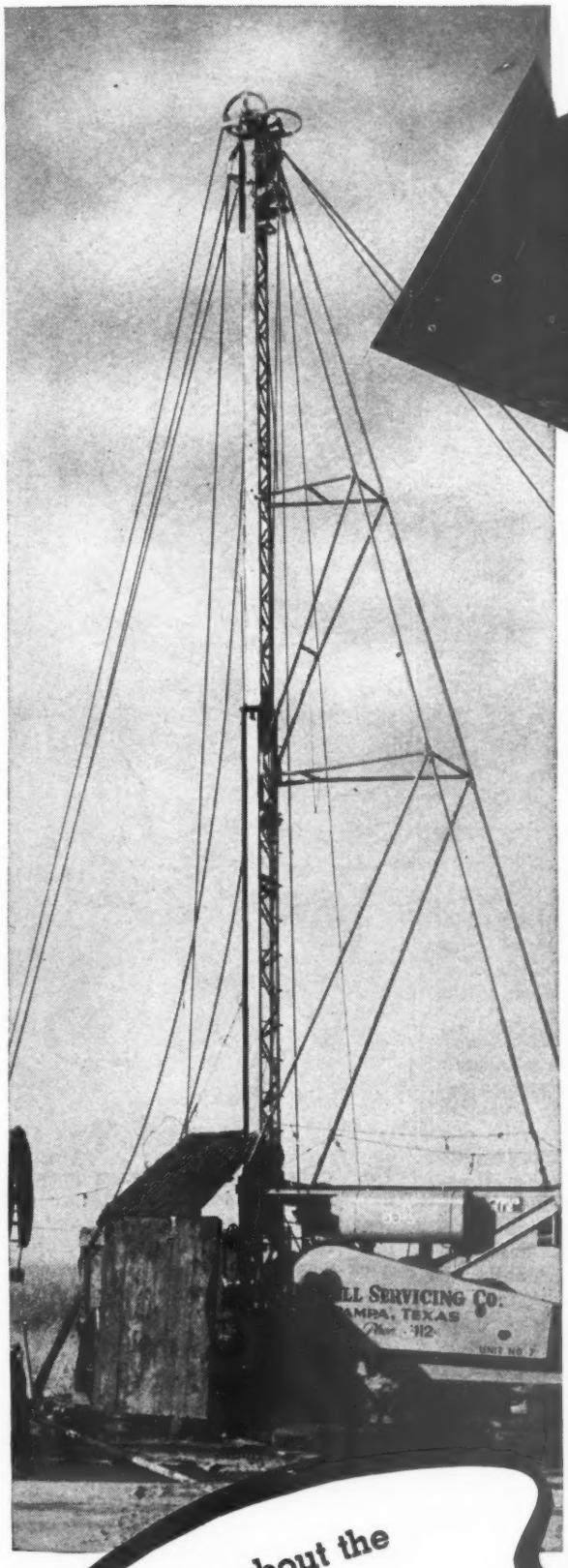

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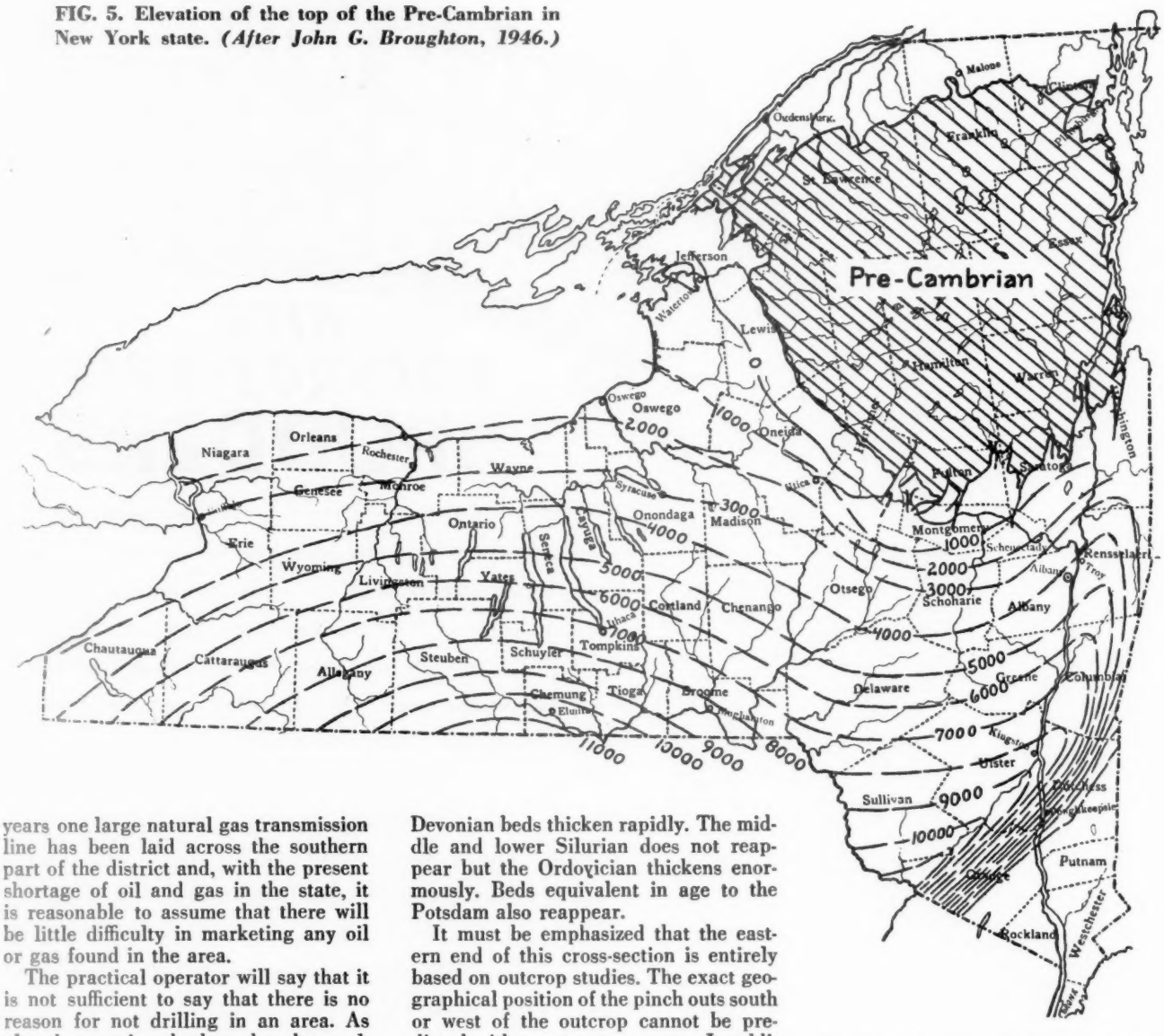
FIG. 5. Elevation of the top of the Pre-Cambrian in New York state. *(After John G. Broughton, 1946.)*



years one large natural gas transmission line has been laid across the southern part of the district and, with the present shortage of oil and gas in the state, it is reasonable to assume that there will be little difficulty in marketing any oil or gas found in the area.

The practical operator will say that it is not sufficient to say that there is no reason for not drilling in an area. As already mentioned, there has been almost no drilling in District 3. As a result it is difficult to make positive statements about subsurface conditions. A study of the formations to the east, north, and west, of the area will, however, permit some general statements.

Fig. 4 shows a cross-section from Buffalo to Albany. The names Rochester, Syracuse, and Utica are included for reference purposes only since the hypothetical line of this cross-section is somewhat south of these cities. This figure has been drawn to illustrate the stratigraphic relationships and the vertical scale is about 40 times the horizontal. It should not be interpreted as indicating the structural position of the rocks.

An item of particular interest is the rapid disappearance eastward of the middle and lower Silurian formations between the longitude of Syracuse and Utica. In a similar fashion the Ordovician thins in the same region due largely to the progressive loss of the upper beds (including the Oswego). The Potsdam part of the column drops out at about the same position.

Along the line of the section, and to the east of the longitude of Utica, the Devonian beds thicken rapidly. The middle and lower Silurian does not reappear but the Ordovician thickens enormously. Beds equivalent in age to the Potsdam also reappear.

It must be emphasized that the eastern end of this cross-section is entirely based on outcrop studies. The exact geographical position of the pinch outs south or west of the outcrop cannot be predicted with any great accuracy. In addition the outcrops are not too well exposed in critical areas so that considerable interpretation is necessary. The major relationship of the formations, however, seems to be fairly well established.

It is hardly necessary to point out that when pinch outs, such as those shown in Fig. 4, are found to coincide with favorable structure they usually produce petroleum. Unfortunately there is almost nothing known about the details of structural attitude of the rocks in District 3.

Fig. 5 was prepared by Broughton,[5] for another purpose but it is included here for two reasons: (1) The map shows the probable elevation of the top of the Pre-Cambrian surface and, therefore, shows the probable maximum depths at which oil and gas may be found in the various parts of the state; (2) the map illustrates the major structural features of the state.

Examination of Fig. 5 shows that there is probably a broad regional high on the Pre-Cambrian crossing District 3 extending south southeast from the general region east of Utica. This Pre-Cambrian high roughly coincides with the Adirondack axis or arch suggested by Kay.[6] If the structure is real it may be sufficient to make the pinch outs shown in Fig. 4 effective traps for the accumulation of petroleum.

Fig. 5 shows the subsea elevation of the Pre-Cambrian surface. In order to find the maximum depth at which petroleum might occur in any area it is necessary to add the surface elevation. In most of District 3, wells 6000 to 9000 ft deep will test the entire Paleozoic section, whereas in a large part of District 2 it will require wells some 3000 ft deeper to penetrate all the Paleozoic beds.

Virtually all the formations that have produced in District 2 might produce in District 3. The middle and lower Silurian and the upper Ordovician are particularly attractive in the western part of District 3. In the eastern part of the area the greatly thickened Ordovician may hold

[5] Unpublished map of Dr. John G. Broughton, assistant state geologist, New York State. Broughton emphasizes that the map is his best guess in the light of existing information and that factual data is very meager.

[6] "Development of the Northern Allegheny Synclinorium and Adjoining Regions," Marshall Kay, *GSA Bulletin*, Vol. 53 (1942) pp. 1601-1658.

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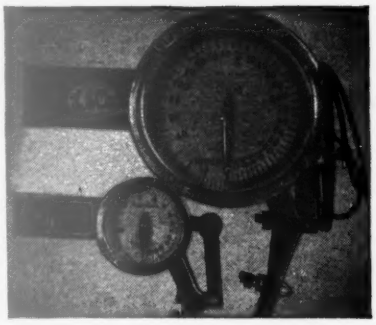

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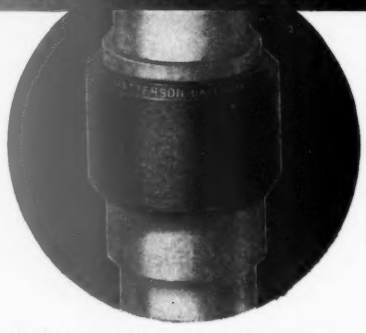

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permeable beds that could produce. Fig. 5 suggests the possibility that a buried Pre-Cambrian ridge may extend under the area. If so the Potsdam part of the column would have good possibilities. Certainly wildcat wells should be drilled as deep as the condition of the hole will permit or until they reach undoubted Pre-Cambrian rocks.

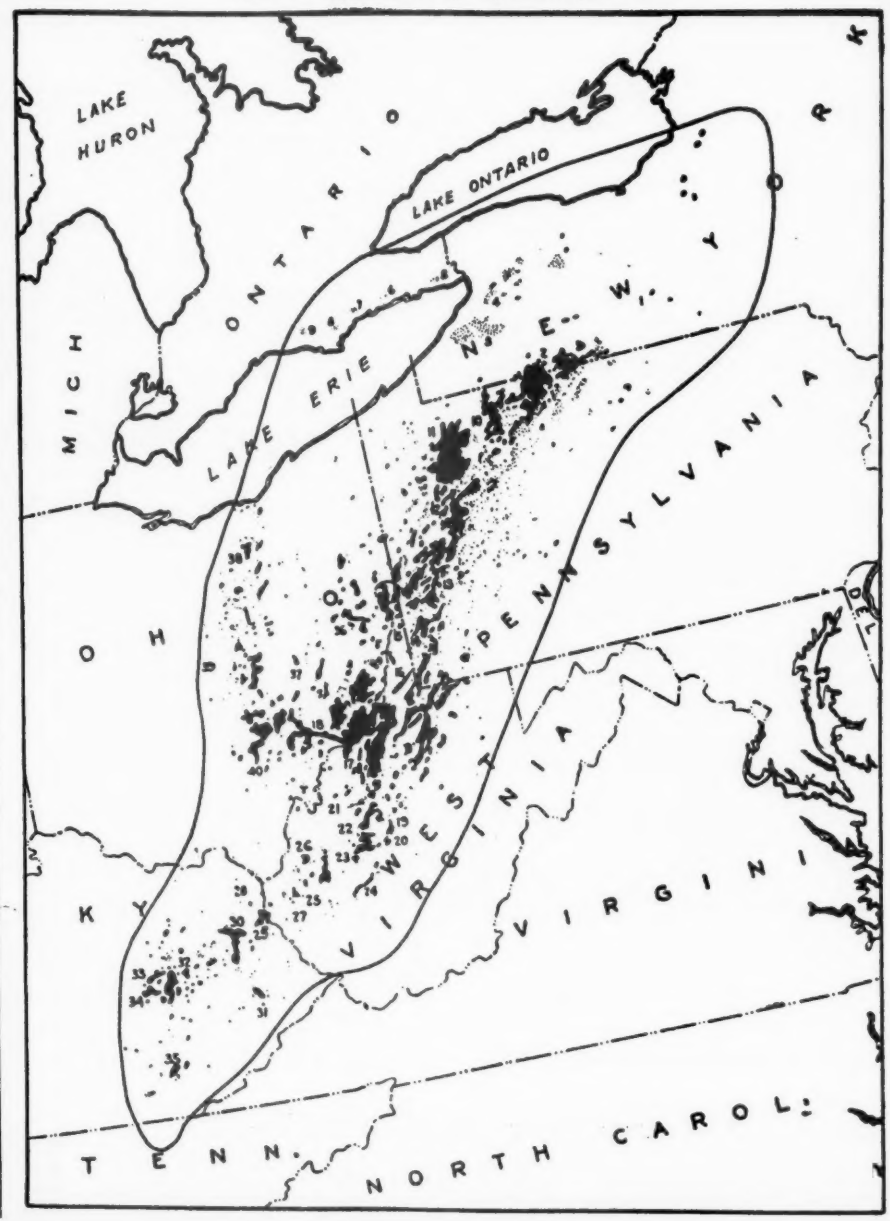
● **Other parts of the Appalachian Basin.** Fig. 6, taken from Ver Wiebe[7] provides an excellent illustration of the way production is arranged in belts along the edge of certain formations. One of the best examples in the production from rocks of lower Silurian age. Starting in New York the productive areas from rocks of this age are indicated by numerals 3 and 4[8]. The belt crosses southern Ontario along 5, 6, 7, 8, and 9. Crossing Lake Erie, production is found in rocks of the same age along 38, 39, and 40. Regional studies show the lower Silurian rocks are usually sandy and always present to the southeast of the productive belt but to the northwest of the belt, rocks of this age are absent or represented by thin shales. Along the belt production is localized by the presence or absence of the sand or by variations in permeability. In Ohio local structures may be important in determining the relative position of oil with respect to gas but, in general, the only important structure is the regional southeast dip.

Oriskany production suggests the presence of a belt similar to the lower Silurian belt. Production is found near numbers 1 and 2 in New York and northern Pennsylvania. Southwestward there is production in and near the tip of the northern panhandle of West Virigina and further southwest there is production of

[7] "Oil and Gas in the United States," A. W. Ver Wiebe, *Science of Petroleum*, Vol. 1, p. 70, Oxford University Press (1938).

[8] Numbers are on Fig. 6.

FIG. 6. Appalachian geosyncline province.



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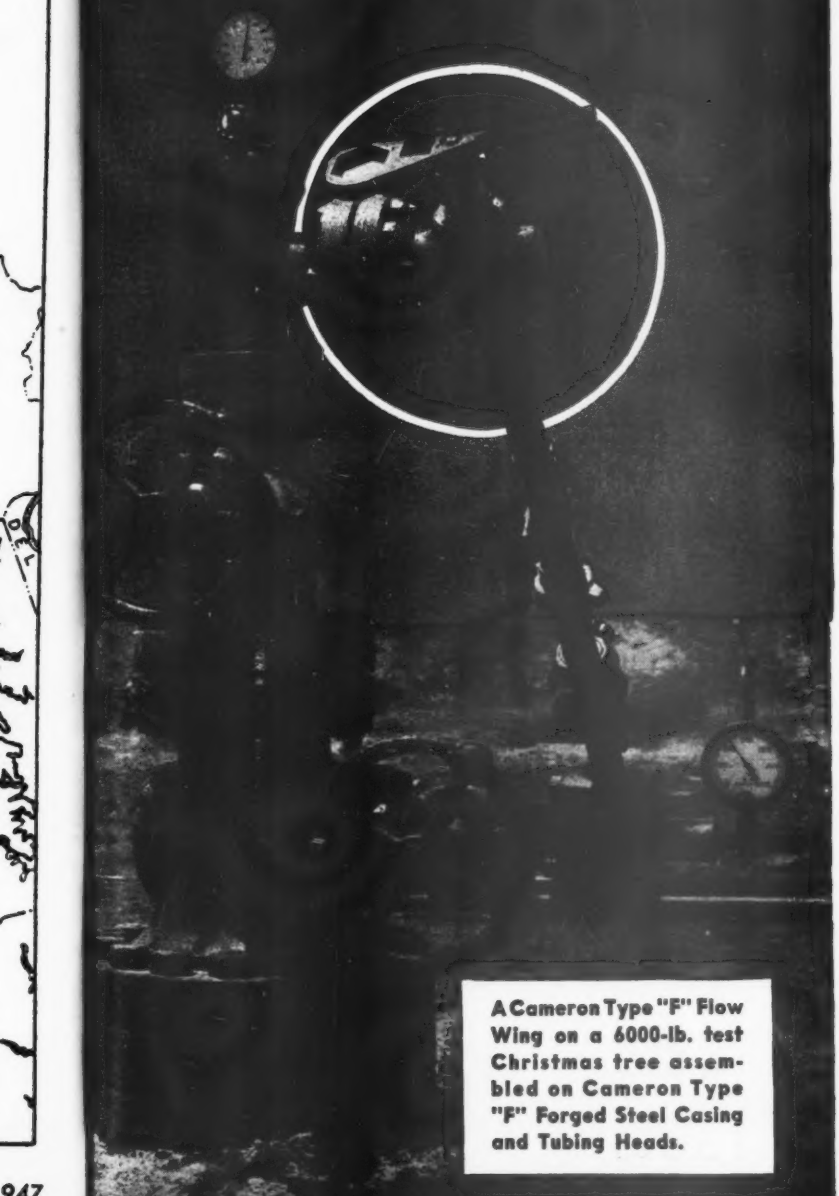

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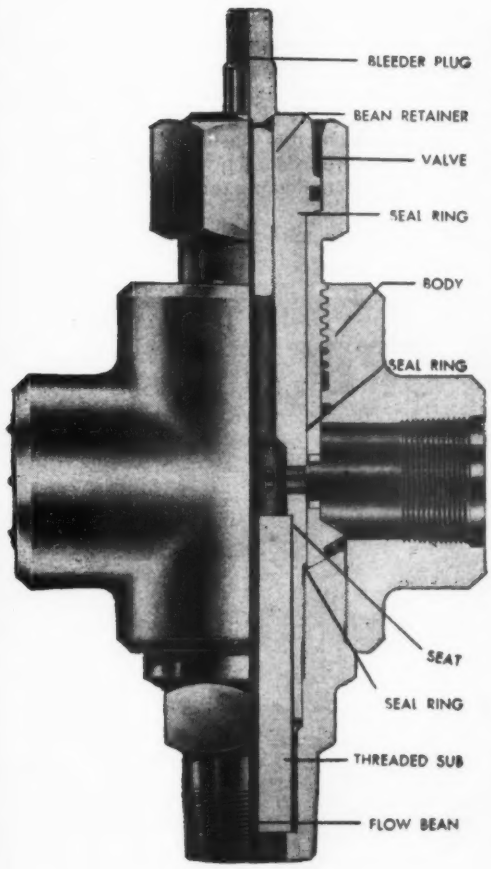

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Note in the accompanying cross-section view that essentially the same valve principle is used as in the earlier and higher pressure models. The stellite seat has proved highly satisfactory for withstanding abrasive flow and provides a dependable shut-off for choke changing. The valve is opened and closed by means of an all-purpose wrench (see picture at left).

The Flow-Wing may be fitted with a positive flow bean as illustrated, or with an adjustable choke, the latter interchanging with the pressure relief plug and bean. The all-purpose wrench is the only tool required for this operation.

To change positive beans you simply fit the wrench to the valve stem and close the valve, back out the bean retainer with the same wrench (the bean is retrieved with the retainer), replace the bean and reverse these operations. As a safety measure, the bean and its retainer cannot be removed until the valve is closed.

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both oil and gas near number 37 in Ohio. The great Oriskany fields of Jackson and Kanawha counties in West Virginia are between and around numbers 21 and 23 on Fig. 6. To the southwest of this belt the Oriskany is present as a sandstone but on the northwest side of the belt the Oriskany is absent or at least not sandy. There are great gaps in the production along the Oriskany belt but these gaps can be attributed to the absence of sand, as in northern Pennsylvania, and to the lack of deep drilling along the northwest edge of the sand. Additional production will probably be found along this Oriskany belt.

No discussion of the accumulation of oil and gas in the Oriskany and associated rocks would be complete without reference to the gas fields of unknown extent along the Chestnut Ridge anticline in southern Pennsylvania, on the same structure in Lewis County, West Virginia, and on the Blackwater anticline in Tucker County, West Viriginia. These are purely anticlinal fields and are far distant from the edge or pinch out of the productive formations. In the writer's opinion the migration and accumulation, (and probably the origin), of the gas in these fields is entirely different from that in the productive belts just described. It is probable that a number of fields of this type will be found when there is more drilling near to, and in, the Folded Appalachians.

There are a number of productive belts or trends in the rocks of upper Devonian and younger age but their position and direction is somewhat obscure due to faulty correlation of the various sandstones. When detailed studies, such as those of Sherrill, Dickey, and Matteson[9] are made for the entire Appalachian region these trends or belts can be more clearly shown. Such detailed studies will, no doubt, result in the finding of several new fields but it is not likely that they will be large fields.

Just as in New York, the chief hope of finding major new production in the rest of the Appalachian region, is to test the older or deeper formations. Areas that have been inadequately tested by past drilling offer even better possibilities of production.

In parts of Ohio and Kentucky the arkosic and sandy beds just above the Pre-Cambrian offer interesting possibilities. Farther east these beds lie at depths that make the cost of drilling test wells prohibitive but in these regions the Ordovician and Silurian have usually not been adequately tested.

Recent developments in southern West Virginia provide an excellent example of the results of intelligent prospecting of an area previously overlooked. Several large gas wells have recently been found in an area that was classified as doubtful or improbable by the carbon-ratio theory. The wells are producing from rocks of Mississippian age. Rocks of this age thicken rapidly to the southeast and most of the thickening is by the addition of new beds. As pointed out above, this is the type of an area that is likely to contain large accumulations of oil or gas.

Farther north in West Virginia, in Randolph and Tucker counties, is a large anticline called the Deer Park anticline. This structure has not been sufficiently tested. Up to 1944 only three wells had been drilled on this structure and only one of these tested the Silurian rocks. The structure is so large that three wells cannot test adequately the Oriskany and certainly one well is not sufficient to test the Silurian. The Trenton should not be more than 8000 ft deep along the crest of this anticline and, although nothing is known about the character of the Trenton in this area, it should be tested. This structure would also be a good place to test the Oswego zone.

In conclusion, it may be said that the Appalachian area is far from "washed up" so far as new production of oil and gas is concerned. Its present status may be considered as similar to that of the Interior Coal Basin of Illinois some 10 or 15 years ago. Oil and gas may exist at great depth in the Appalachian region but wells less than 10,000 ft deep will test many zones and areas that may produce.

[9] "Types of Stratigraphic Oil Pools in Venango Sands of Northwestern Pennsylvania," R. E. Sherrill P. A. Dickey, and L. S. Matteson, A.A.P.G. Stratigraphic Type Oil Fields, pp. 507-538, 1941. Also reports by these authors published by the Pennsylvania Topographic and Geologic Survey. ★★★

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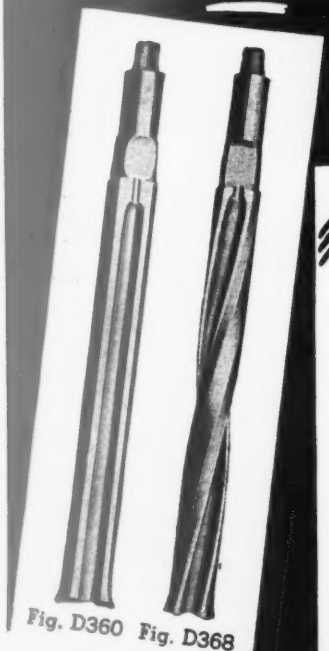

Fig. D360 Fig. D368

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Changes in pipe line construction methods*

By T. A. HESTER, Oklahoma Contracting Company

THERE is probably very little I can tell you about pipe line construction as you are all engaged in some phase of the oil or gas business and know that there are thousands of miles of oil and gas lines in operation today in this country and abroad. As I have been actually engaged in pipe-line construction for a contracting firm for 18 years, however, you might be interested in some of the changes that have occurred in the business during this time.

The first change that I would like to note is in the people who follow pipeline construction for a livelihood. Most of the workers in this country used to be foreigners, and only a few of them could speak English. The contractors set up large camps for the gangs that ranged from 100 to 500 men. Frequently these foreign groups would have their own interpreters, who also served sometimes as business agents. The work was almost all done by hand, and these men were excellent workers. They enjoyed camp life, for the food and the pay were good.

In contrast to these "old-timers," our machine age has developed a new kind of a pipeliner. It is not uncommon today to find an engineer or two around a pipe line job. Most of the men are usually young and highly skilled. Most of these new pipeliners are married, and they take their families with them to the job. Some own trailer houses, but usually they depend upon procuring apartments or housekeeping rooms in the towns where the contractor has his headquarters. Many have children of school age, and, believe it or not, some of the most intelligent children I have ever seen are these pipeliners' children, who have attended four or five schools in one year in as many states.

This new pipeliner is a very responsible citizen. He is skilled in his trade as a machine operator, welder, or foreman. He earns from $500 to $800 per month. He saves his money and many have purchased farms, ranches, or shops on which to retire when the "going gets rough."

● **Pipe line work becomes mechanized.** The second change in our business is the change in equipment and technique. The president of our company says that he used to haul his entire spread of equipment in a farm wagon, whereas, it takes a trailer load of equipment to do a job today.

In the early days, all the work was done by hand. The ditch was dug by hand, and the pipe was screwed or coupled together by hand. Bends were made by using men for weight, and the backfilling was done by team and mormon board. If one were to attempt to lay a long line today using old methods and techniques, it would take a lot of men a long time to complete the job, and the cost would be prohibitive. Surprisingly enough, however, the old lines were laid relatively fast and, in many cases, at less cost than some of the lines today. The low cost was, of course, due to the low wage scales prevailing in those times and the fact that the men worked more hours during each day.

I think you might be interested in some of the highlights of our job in South America. My partner and I flew to Venezuela in February to inspect the job and to make a bid for its construction. The job was laying 110 miles of 16-in. from an oil field in the interior to the port of La Cruz. Contrary to practice in this country, this line was to be laid on top of the ground and not coated.

We spent a week down there trying to obtain all the information possible, but as we could only see the right-of-way in a few places and could not speak Spanish, our data was meager at the best. We were awarded the job in March, 1946. Construction was not to begin until July 15, so we had 4½ months to get ready and move down there, and, believe me, we needed every bit of that time.

We had to take from this country everything we needed to do the job. Not only did we have to take tractors, draglines, bulldozers, welding machines, but we had to take all the camp equipment necessary to feed and house 50 Americans.

Some pipeliners who are content to live in cheap rooming houses in this country will want and demand Waldorf-Astoria accommodations when they are employed in a foreign country. We bought 25 prefabricated houses for this job. Three of them were joined together for a kitchen and mess hall, and two were joined together for a bathhouse. The rest were used for office and sleeping quarters. One was erected about 150 ft from camp for card games. This house, incidentally, was used every night and the stakes were high, much too high for me. It was not uncommon for 3 or 4 thousand dollars to change hands every night.

The pipe for this job was shipped to Port La Cruz. The line was begun at that point and laid toward the oil field. We employed about 200 nationals, and, after having about 100 per cent turnover, we wound up with a good gang of workers. The American foremen finally learned a little Spanish and the Venezuelans learned more English. Thoughts were expressed, orders were given, and the work moved along fairly well.

The first 40-mile leg of the job was mountainous, and the next 70-mile leg was in high level country similar to West Texas. Considering our language handicaps, the shortage of parts, particularly tires, we made fair progress and averaged about 5000 ft per day. We had one 17,000-ft day, but, of course, had many 1000 and 1500-ft days.

While I was down there, I thought it was the toughest job I had ever been on, but looking back at it now, it wasn't so bad, and I am glad to have had the experience.

● **Present methods of laying pipe lines.** I think the best way to describe present day pipe-line construction in this country is to tell you how we are laying a 20-in. line in Kansas.

We were awarded this job about the middle of January, 1947, and were advised that pipe would be received for construction by the middle of February. The first thing we did was to send a paymaster to the town we selected as the most centrally located for our headquarters. His duties were to rent a warehouse and yard for storage, office space, and parking space for about 20 trucks. Also, he was to contact the Chamber of Commerce and find out where vacant rooms, apartments, and dwellings might be obtained for the gangs of men and their families that would soon arrive. While the paymaster was accomplishing these things at the headquarters town, we had about 15 mechanics checking and loading equipment from our warehouse in Dallas. As this job was only about 500 miles away, we decided to truck the equipment. It required 25 low-boy or tractor-truck-trucks and 15 ordinary 1½-ton trucks to haul the equipment from Dallas to the job in Kansas.

When our equipment was on the job, we began the right-of-way. A small crew consisting of a straw boss and four or five men began making gaps in the fences. These gaps were made 50 ft wide to provide plenty of room for the equipment.

We dispatched a clearing gang to follow the fence gang. This gang consisted of 15 or 20 men with a winch tractor and several power saws. Its job was to cut all the timber flush with the top of the ground. Commercial-sized trees were to be cut into 12-ft lengths and trimmed, and the brush was to be stacked, so that it might be burned later.

The right-of-way grading gang followed the clearing gang. This gang was

*Presented before the Petroleum Engineer's Club of Dallas on June 6, 1947.

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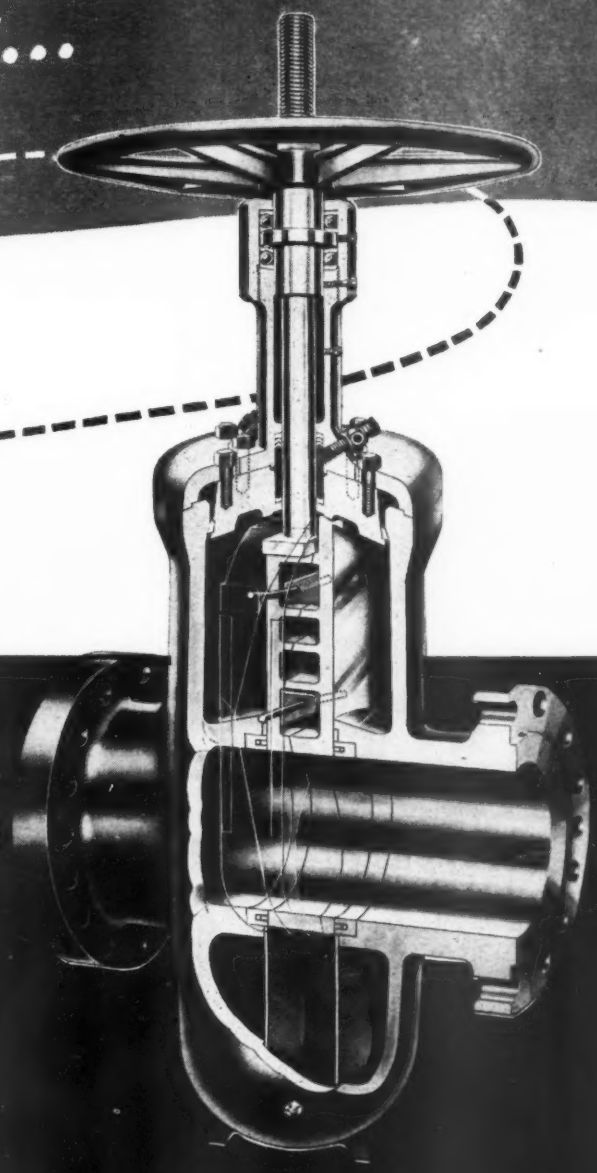

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- A full-bore round opening entirely through valve when open . . . no turbulence, no restriction of flow.
- Parallel expanding gates . . . seal directly across both seats with no distortion whatever—positive shut off both sides.
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- Lubricant contained in entire body—no special lubricant required—seal does not depend on lubricant.
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- Chrome Plated Gates.
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every joint, making the joints the strongest part of the line. In case of shock, strain or vibration the pipe will fail before the reinforced joints. Many engineers today are saving money and getting faster and better jobs with WEDGE Chill Rings. It will pay you to get all the facts about this efficient welding method.

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equipped with two large bulldozers. Its job was to smooth out the right-of-way and, in general, make fair second class road.

After the right-of-way had been prepared in this manner, the unloading and stringing gang was activated. This gang unloaded the pipe by means of gin or boom truck from the railway cars onto trucks equipped with semi-trailers. Then the pipe was hauled to the right-of-way where it was unloaded by means of a boom or crane tractor. Large diameter pipe cannot be unloaded from trucks by simply rolling it off. The tractor picks up a joint, and the truck drives out from under it. This operation is continued until the truck has been unloaded. Large pipe trucks usually hauled five or six joints. In addition to the boom tractor for the stringing gang, it was also necessary to have one or more winch tractors to pull the trucks through muddy country and up steep grades.

After the pipe was strung, the ditching gang began operating. This gang consisted of about 50 men with two large wheel-type ditchers, three or four draglines with pull-shovel attachments, six or eight air compressors, hand tools, etc. In "good digging," there was very little work to do behind the ditchers; however, when rock was encountered, it was necessary to drill and blast. After the rock had been dynamited, the pull-shovels cleaned out the loose rock. These shovels work astraddle the ditch. After the ditches were cleaned out by the shovels, a hand gang put in 3 to 4 in. of dirt, as coated pipe cannot be lowered into a rough ditch in hard rock without damaging the coating.

After the ditch was dug and prepared, the bending gang was sent into action. This was a small gang consisting of an engineer, a foreman, and 10 or 12 men with a sideboom tractor and bending machine. Its job was to measure the ditch, measure the pipe, and bend the pipe where necessary to fit the curvature of the ground. In other words, all bends are made to fit the grade of the ditch. The bends may be "sags," "overbends," or "side-bends." Then the pipe is simply turned to fit the ground.

After the pipe was bent, the lining-up or laying gang began to work. This laying gang consisted of two sideboom tractors, two welding machines, and 15 or 20 men. Its job was to line up the pipe, that is, the pipe was laid a joint at a time, and the joints were connected by welding a "stringer" bead. This was the first bead made by a welding crew.

The welding gang followed the laying gang. The welding gang consisted of about 10 welders and welding machines. These men finished the weld begun by the laying gang, that is, they applied the last two or three beads, depending upon the thickness of the pipe. Each welder and his machine is placed along the line so that he may make from three to four welds before being moved forward. The welding machines are mounted on rubber-tired wagons, and the wagons are moved when necessary by means of a tow-tractor. Two tow-tractors are assigned usually to each welding gang. As the welders rarely finish at the same time, the two tractors have ample time to move them ahead without much delay.

First leg of the 1200-mile pipe line from Kirkuk (Iraq) to Tripoli (Syria) and Haifa (Palestine) will be completed this year; entire line in 1949. This will add about 90 million bbl of crude annually to present facilities.

★ ☆ ☆

After the pipe was welded, the paint gang began its work. This gang had two large sideboom tractors and a combination cleaning and painting machine. The two tractors carried the pipe on dollies, which we call cradles. In other words, the pipe is carried about 2 ft above the ditch as the tractors are continuously moving forward a short distance ahead of the cleaning machine. The cleaning machine has its own traction power with "crawlers" on top of the pipe.

After the paint had dried sufficiently (usually in about three hours), the doping crew was put to work. This crew had two large sidebroom tractors and a combination doping and wrapping machine. These tractors also carried the pipe on cradles in the same manner as the paint tractor. The coating and wrapping machine traveled along the pipe and applied a thickness of coating varying from 3/32 to 5/32 in. and a spiral wrapping of asbestos felt or Fiberglas. The wrapping covers the hot dope so that the whole layer is completely bonded to the pipe. After the pipe was coated and wrapped, it was lowered into the ditch by the lowering-in gang. This gang had from two to four large sideboom tractors. Most of the pipe is lowered-in during the day, that is, 600 to 700 ft is lowered-in, about 200 ft is left on skids above the ditch. Dirt is filled in on the part lowered-in during the day, and the next morning before daylight, or before the temperature has risen, the same crew goes out and lowers these unlowered portions, which are called slack loops. The purpose of lowering-in pipe in this manner is to get as much pipe in the ditch as possible, in order to take care of expansion and contraction.

After the slack loops were lowered, the backfill gang filled the trench, cleaned up the right-of-way, and repaired the fences. Cleaning up the right-of-way includes rounding terraces, filling in cuts made by the right-of-way gang, and, in general, leaving the right-of-way in a neat and clean condition and as much as possible in the same condition as it was before the work was begun.

I think it will be well here to mention our office system, for, after all, the office handles the details of spending from $5000 to $7000 per day. Our usual office force consists of a paymaster, who, in reality, is office manager; a timekeeper, and two time-checkers. The time is kept in the field and mailed weekly, to our Dallas office, where checks are written and mailed to the paymaster for distribution to the men. ★★★

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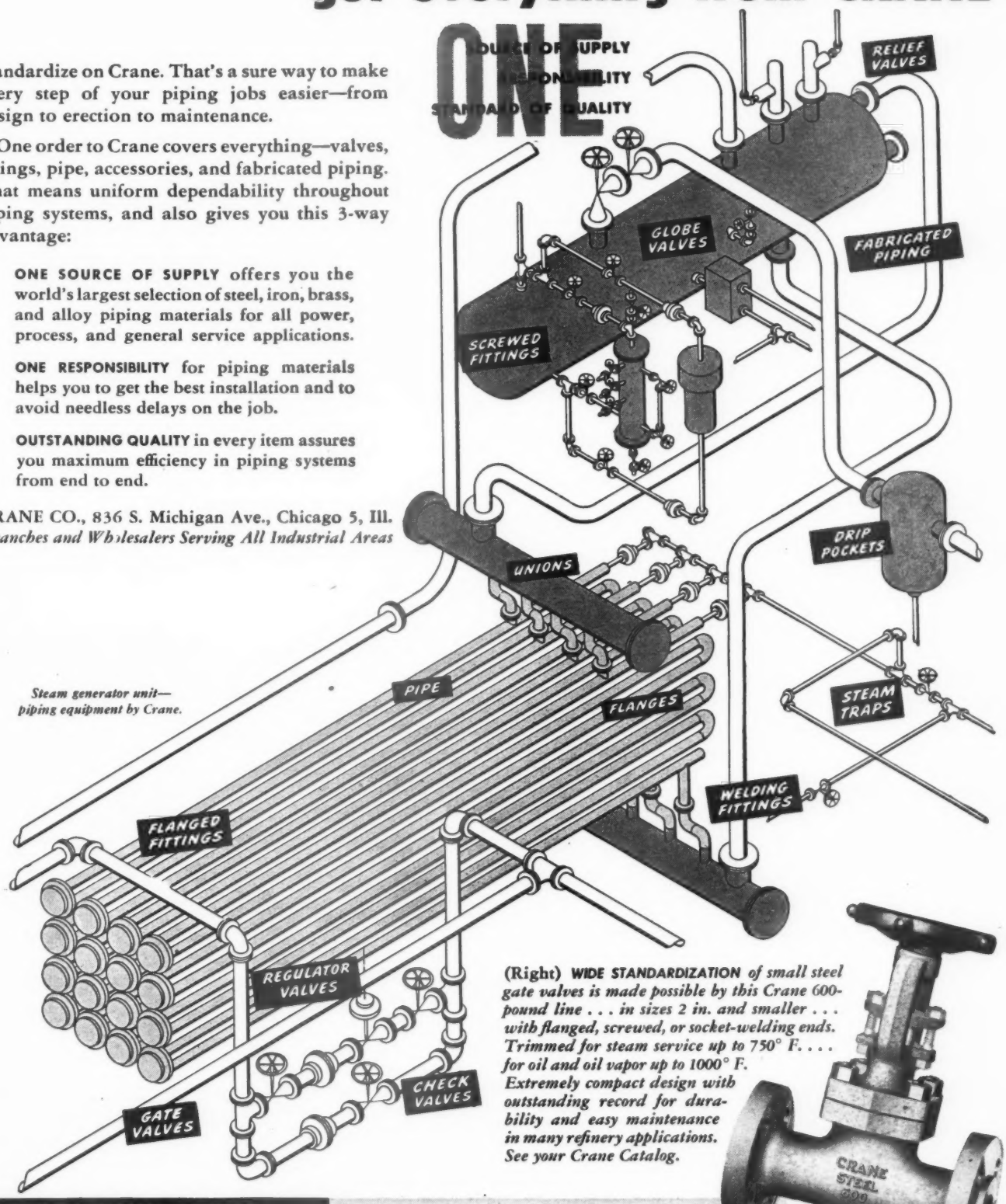

Steam generator unit—piping equipment by Crane.

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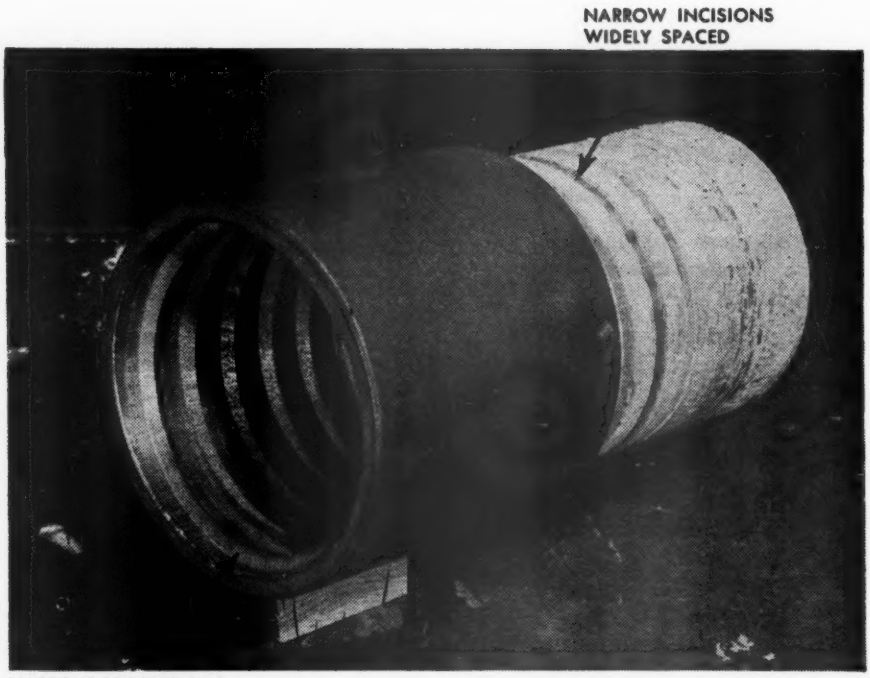


FIG. 1. The coupling that suggested use of a metal spiral thread to join the sections of asbestos-cement pipe and rustless coupling.

Rustless coupling for asbestos-cement pipe[1]

By FREDERICK SQUIRES[2]

A STUDY of rustless pipe was made in 1945 by the Illinois State Geological Survey in an effort to find a successful means of combating oil-field corrosion in lead lines and casing for salt water disposal wells. The work described in Circular 120[3] was continued and culminated in the improved design of the coupling herein described.

EXCLUSIVE

Fig. 1 is a photograph of a section of threaded asbestos-cement pipe connected by a threaded cast-iron coupling. In it the projecting threads on the coupling are narrow in section and widely spaced. On the asbestos-cement pipe, the incisions are narrow in section and widely spaced, to provide a great thickness of the asbestos cement material between incisions to resist stripping. The thin widely spaced projecting metal threads in the coupling have a greater shear resistance than the material between the incisions on the asbestos-cement pipe.

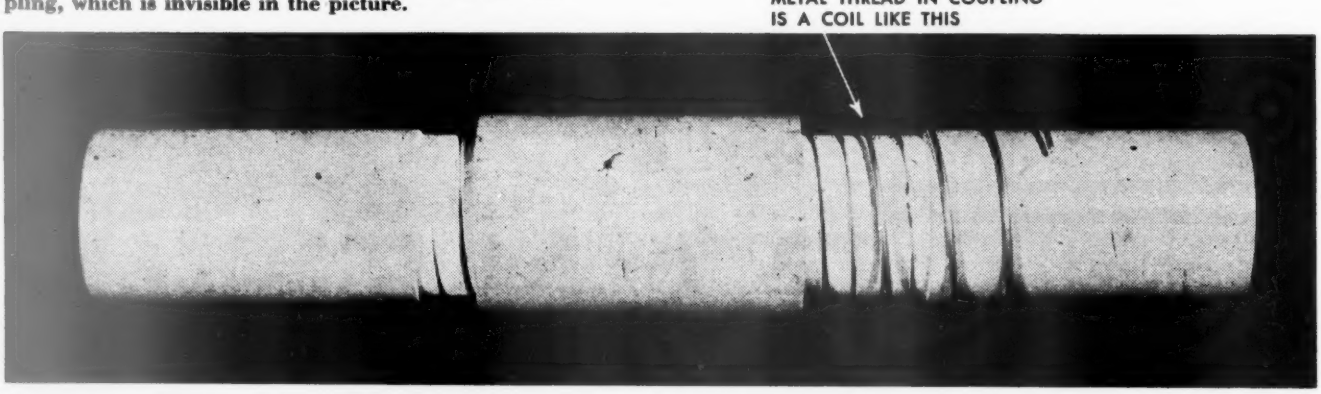
From this combination of metal coupling and asbestos-cement pipe came the idea of the incised all-asbestos-cement pipe and coupling with spiral metal projecting thread. This is shown in Fig. 2 and in the scale drawing, Fig. 3. The

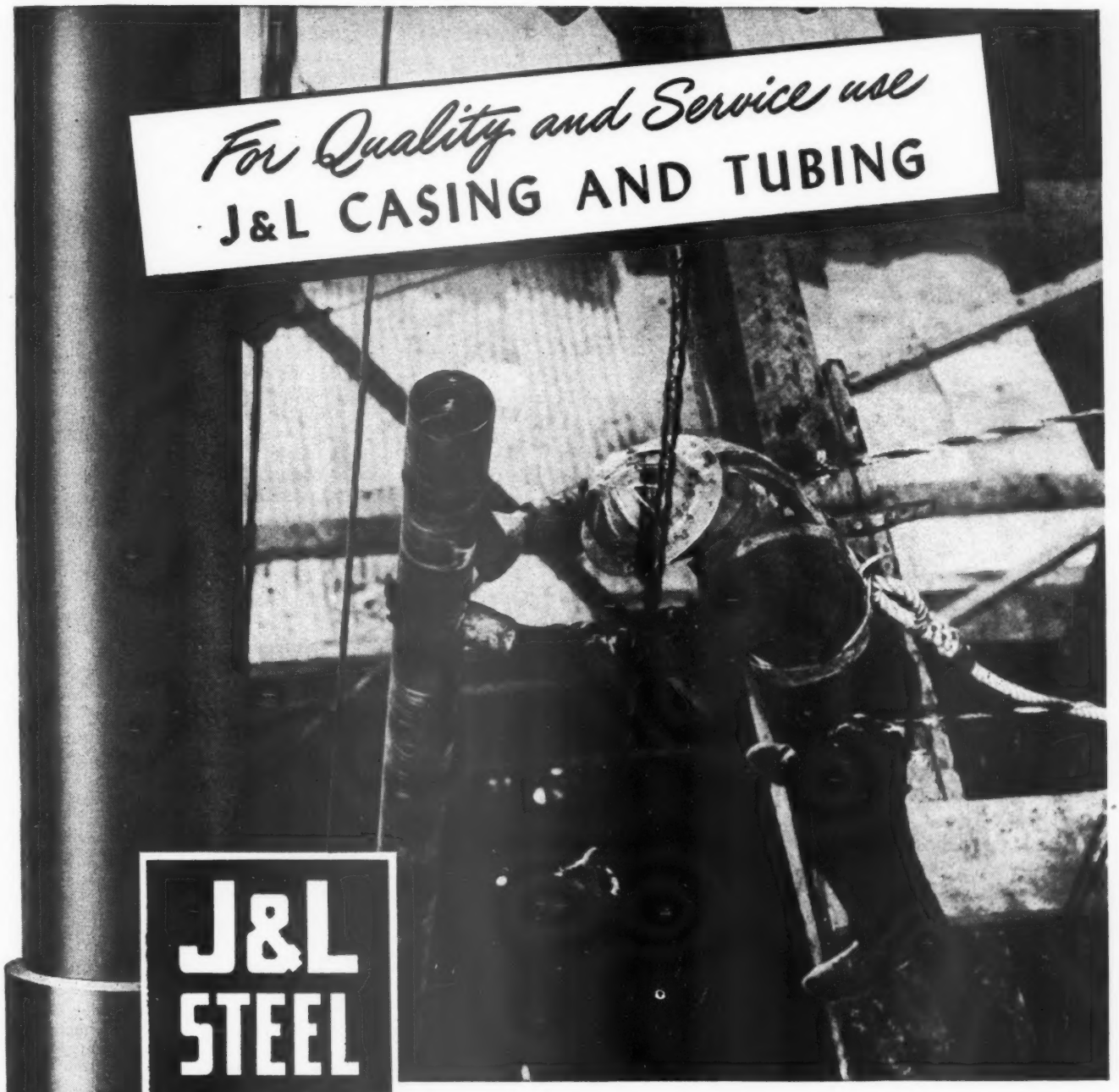
[1]Published by permission of the Chief, Illinois State Geological Survey.

[2]Petroleum Engineer, Illinois State Geological Survey.

[3]Squires, Frederick, "Rustless Pipe for War and Peace," *Oil and Gas Journal*, Vol. 44, August 4, 1945; Illinois Geological Survey Circular 120, 1945.

FIG. 2. Asbestos-cement pipe and coupling assembly, and spiral metal thread is shown on outside of one section of pipe to illustrate the kind of thread in the coupling, which is invisible in the picture.





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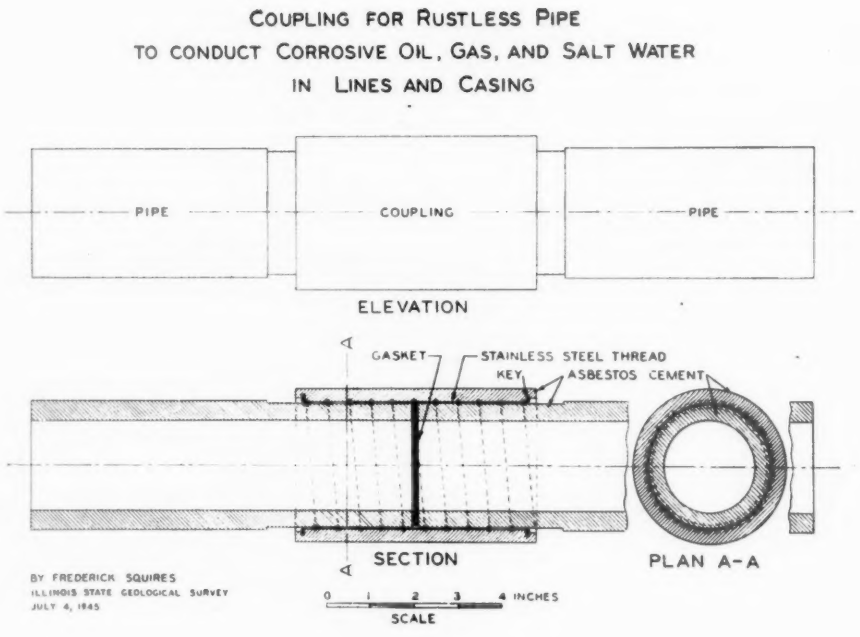

FIG. 3. This is a scale drawing showing the way in which the three materials, asbestos-cement for pipe and coupling, rubber gasket, and spiral metal thread are combined to produce a corrosionless assembly. Corrosive fluids cannot come in contact with corrodable material. This assembly solves the corrosion problem for lead lines and cemented-in casing for salt water disposal wells.

thread is locked into the coupling at each end so that the thread cannot back out with the pipe when the joint is unscrewed. A gasket is provided between the pipe ends, which is compressed when the pipe is coupled up tight. Corrosive fluids traversing the pipe and coupling can never come in contact with any corrodable material. Such an assembly solves the corrosion problem for lead lines and cemented-in casing for salt-water disposal wells. ★★★

United States Obtains New Mexico Helium Rights

PRESIDENTIAL approval of an act of Congress ratifying agreements with the Navajo Indian Tribe and two private oil companies further strengthens the United States' position for world control of helium, the lightweight, noninflammable gas that played an important role in World War II and has even greater prospects in peacetime, Secretary of the Interior J. A. Krug has disclosed.

The act ratifying agreements that grant the United States' future control of the helium-bearing gas in the Rattlesnake field in New Mexico on the Navajo Reservation was signed by President Truman on June 27, ending a five-year effort of the Bureau of Mines to place the helium-bearing natural gas in this field in the status of a Government reserve, Secretary Krug said.

The Rattlesnake field, covering some 7800 acres in San Juan County, New Mexico, produces gas containing 7.63 per cent of helium, considerable carbon dioxide, and a large amount of nitrogen. This concentration of inert constituents renders the natural gas noncombustible. The Rattlesnake field is known as a high pressure field, the wellhead pressures of two wells already drilled on the property being about 2850 psi.

In acquiring the rights to this field, the Department of the Interior will pay the Navajo Tribe $147,799 as advance royalty and rental for 25 years, and will pay $166,594 to two oil companies for rights in their prior leasehold interests in the area. Funds for these payments, which are based on careful evaluations, are available from the unobligated balance of the appropriation, "Construction and equipment of helium plants," which was appropriated for the fiscal year 1947, but not renewed for the fiscal year 1948.

Payments to the Navajo Tribe represent the present worth of 12½ per cent royalty on an estimated volume of helium-bearing gas in the Rattlesnake field and of rental at 25 cents per acre per year for 25 years. Royalties on production other than helium-bearing gas, on helium-bearing gas in excess of the tentatively-estimated volume, and rentals beyond the 25-year advance, will be paid as they accrue.

The money to be paid by the department to the oil companies represents the value of rights conveyed by the companies to the department less the value of rights conveyed by the department to the companies. These concerns will continue certain payments to the Navajo Tribe for rights and royalties on production other than helium-bearing gas.

Drilling for oil in the Rattlesnake field has been under way since 1923 when a lease now owned by the Continental Oil Company and the Santa Fe Corporation was granted on 4080 acres on the Indian Reservation. In January 1942, the Continental Oil Company acquired a lease from the Navajo Tribe on 3720 additional acres adjoining the original grant.

The helium discovery was made in this latter acreage during June 1942, at a time when the Bureau of Mines was seeking a suitable site for the fifth plant in a $16,000,000 wartime helium-plant expansion program.

The discovery well, known as Navajo No. 1 and drilled by the Continental Company, yielded the high helium-bearing natural gas at a depth of about 7000 ft. After careful checking of the formation and well data, the Department of the Interior procured the lease from this company on the 3720-acre tract for $1, as the first step in a series of transactions to gain control of the gas rights. Subsequently, a second well, the Rattlesnake No. 1-G, was drilled on the original 4080 acres, which still were leased by private companies. This well, likewise, yielded high helium-bearing natural gas under high pressure.

Construction of a helium-plant to process this gas was started by the Bureau of Mines in April 1943, near Shiprock, New Mexico. The plant was placed in operation on March 11, 1944, and as the demand for helium had abated by that time, the plant was placed in standby condition after an 18-day trial run. Thus, this important addition to the Government helium resources is virtually untapped and has been carefully preserved for future use.

At the present time, the Bureau of Mines, sole producer of helium in the world, has helium plants at Shiprock, New Mexico, Amarillo and Exell, Texas, and at Otis, Kansas. The Exell and Otis plants were built to process raw natural gas owned by private companies flowing to commercial markets, but with the closing of the transactions concerning the Rattlesnake field, the withdrawal of helium-bearing natural gas at both Amarillo and Shiprock will be under Government control. Current demands for helium are being met by the Exell plant alone and the other three plants are held in standby status available for the resumption of production on short notice. ★★★

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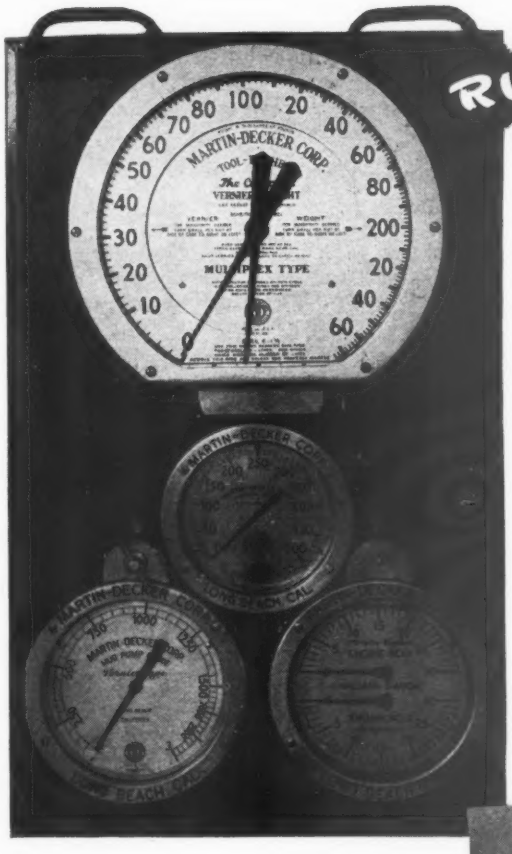

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IT'S COMPACT and COMPLETE—Weight Indicator and Vernier Indicator, Mud Pressure Indicator, Steam Torque Indicator and Rotary Table Tachometer are mounted and protected in a compact, strong 16" x 16" x 26" steel box. All indicating gauges are available with recorder except the Rotary Table Tachometer.

IT'S MODERN—Immediately adaptable to any type of rig, large or small. The latest thing for use with mast, jackknife, folding derricks or any rig with limited floor space.

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Nomad regents honored by Dallas party

Seated at the head table at the Dallas Nomads' cocktail and dinner party recently, honoring the national regents of the organization are, left to right: C. A. McClelland, Dallas member of the regents; Henry A. Bourne, Tulsa regent; William B. Way, manager of the International Petroleum Exposition, Tulsa; Captain L. D. MacGregor, USN, who presented a moving picture of submarine operations in the Pacific; N. A. Endicott, president of the Dallas chapter; C. W. Thornhill, Houston regent; Jacques Villere, manager of the foreign banking department of the Mercantile Bank in Dallas; Floyd Senter, Houston regent; H. M. Cosgrove, Tulsa, national secretary of the regents, and S. Pete Parker, Dallas regent.

Behrhorst to California

W. F. (Bill) Behrhorst, who for several years has been district representative in Kansas for American Iron and Machine Works Company, has been transferred to California district. He will make his headquarters in Whittier.

W. F. Behrhorst

Prior to his connection with American, Behrhorst was for many years with Oil Well Supply Company and Bethlehem Supply Company. Prior to that he had worked for several contractors and production companies.

All American sales in California will be through supply companies, as they are in the Mid-Continent area.

New Ludlow president

Oliver F. Gang has been elected president, director, and general manager of the Ludlow Valve Manufacturing Company, Inc., succeeding Alfred W. Thompson, who becomes chairman of the executive committee and continues as treasurer of the company.

Gang goes to the Ludlow company from the William Powell Company of Cincinnati and New York, manufacturers of valves, from which organization he resigned on June 30 as vice president and consulting engineer. From 1919 to 1931 he was sales engineer for the Lunkenheimer Company of Cincinnati, valve manufacturers. During World War II, he was a member of the valve and fittings industry advisory committee of the War Production Board. He also served as a member of the Marine Committee of the Manufacturers Standardization Society. He is a former vice president and director of the Valve Manufacturers Association and is licensed by the U. S. Department of Commerce as a chief engineering officer of ocean vessels of unlimited tonnage.

Thompson joined the Ludlow company in 1935 as vice president and succeeded Livingston W. Houston as president in 1939.

Open Virginia store

The opening of an oil-field supply store by The National Supply Company at Rose Hill, Virginia, in the middle of the newly discovered field in Lee County, in the western tip of the state, is announced by E. N. Smith, division manager. The field is reported to be the first in Virginia to produce oil in any quantity. The oil is of high quality, being classed as Pennsylvania Grade.

The new National Supply store is now in full operation with J. Gordon Martin as local manager, under the supervision of J. C. Jett, Kentucky district manager at Paintsville, Kentucky.

Lenzen general manager

Appointment of T. L. Lenzen as general manager, Eastern Hemisphere Operations, has been announced by Standard of California.

T. L. Lenzen

In this new position Lenzen will continue, on an expanded scale, the duties he has performed since 1944, when he was made assistant to the vice president, foreign operations. His work will include contact with the foreign producing and marketing companies in the Eastern Hemisphere with which Standard is affiliated, and with the stockholders of these affiliated companies.

ASME president

The 1947-1948 president of The American Society of Mechanical Engineers will be E. G. Bailey, New York, vice president of The Babcock and Wilcox Company, manufacturers of steam generating equipment. Bailey was nominated for the office at the semi-annual meeting of the society, held in Chicago June 15-19. Nomination is tantamount to election, since only one nominee is named for each office. He will succeed Eugene W. O'Brien of Atlanta.

new and improved machinery *and* equipment

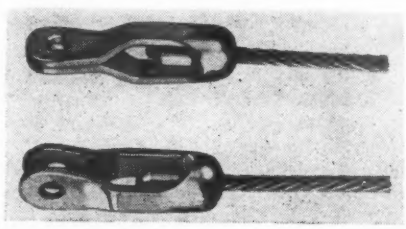
A REGULAR FEATURE
appearing in
THE *Petroleum* **Engineer**
Irwin-Keasler Building
Dallas 1, Texas

(1) Cable terminals

Macwhyte Company, wire rope manufacturers, Kenosha, Wisconsin, are now making the "Socketype Cable Terminals" formerly made by Paulsen and Nardon, Inc., Los Angeles.

These terminals consist of an alloy steel cadmium plated eye or fork type fitting, plus a stainless steel sleeve for swaging to cable (wire rope). They are available loose or attached to the rope in a complete cable assembly to specification length.

Formerly known as the PN socket type cable terminals, they are now called "Macwhyte Socketype Cable Terminals."



Literature says that they have been approved by the Civil Aeronautics Administration for use at 100 per cent of the rated strength of the cable to which they are properly attached. Further, it is said that these terminals save cable, allow the cable to swivel freely when load-free, which eliminates kinking. They provide a safe, smooth, foul-free installation, it is asserted.

(2) Water bags

The H. Wenzel Tent & Duck Company of St. Louis, Missouri, manufacturers of drinking water bags and tarpaulins, announce a new type large size canvas water bag for use in carrying drinking water to men working on petroleum projects. Called the "Water Boy," this new drinking water bag has a complete shoulder harness and apron that straps to the back of a water carrier, enabling him to climb ladders and "make the rounds" wherever men are working, thereby eliminating the necessity of men leaving the job. It is equipped with a sanitary chrome spigot at the bottom, which can be used either as a faucet to fill cups, or can be turned up and used as a bubbling fountain.

Although canvas water bags have long been used, and have been standard equipment for years with labor crews on jobs such as New Mexico State Highway Department, U. S. Forest Service and Atchison, Topeka and Santa Fe R.R., this is the first time a drinking water bag of this type and size has been available in the petroleum field. Made of heavy canvas, it allows water to slowly seep through, and be evaporated by the air, thereby keeping the drinking water inside the bag cool and fresh throughout the day. This new drinking water bag holds 5 gal, and when not being carried, apron and harness can be removed and the bag hung nearby for use by a group of men or transported on the side of a truck.

It is planned to sell these new drinking water bags through Construction Equipment Distributors.

(3) Tachometer

Jones Motorola Corporation, Stamford, Connecticut, announces the Jones tachometer and electronic control for use as a safety or control device on machinery.

By setting the red indicator hand of the tachometer, the maximum speed of the equipment can be controlled. When the predetermined speed is attained, the electronic device actuates a relay that will shut off the equipment, ring a bell, flash a light, or any other operation that is required.

The tachometer is of the centrifugal type. Stray electrical currents or close proximity of large electrical units do not affect the readings. Likewise, extreme temperature changes do not interfere with its operation, according to the manufacturer. Instruments can be supplied with indicating dial in any terminology desired, it is stated.

The electronic control operates on a tiny current flow of only 3/1,000,000 amp. This small current is then amplified more than a thousand times to energize a relay that accomplishes the required task.

Replacement of the 6J5 vacuum tube after each 5000 hr of service is the only maintenance required.

(4) Fluidyne pump

Peerless Pump Division of the Food Machinery Corporation has introduced a single stage, end suction, vertical split case centrifugal pump designated as the Fluidyne, an economical, general utility centrifugal pump, with power drives from fractional to 20 hp.

The Peerless Fluidyne is being manufactured in two types, both of which are capable of moving water and other liquids in capacities up to 1000 gpm against heads up to 270 ft. The Fluidyne type PE is an integrally coupled, compact electric unit in which pump and driving motor are anchored on the motor footing. The type PB is a belt driven unit with the iron frame and bearing mounts supporting the various pump sizes integrally cast. The latter type pump is either keyed to a V or flat belt pulley, as desired, or direct connected to a standard horizontal electric motor by means of a pin type flexible coupling.

The Fluidyne may be installed and will operate in any position—vertical, horizontal, or intermediate angle. Ease of maintenance and accessibility are stressed in the design of both types of pumps and it is stated that close attention to hydraulic characteristics results in units of high efficiency. Eight or more positions of the discharge opening (depending upon pump size) provide flexibility of installation.

A new Bulletin, No. B-165, illustrating and describing both types of these pumps and their applications, has been issued by the manufacturer, Peerless Pump Division, Food Machinery Corporation, 30 West Avenue 26, Los Angeles 31, California.

(5) Power swivel

The Baash-Ross Tool Company, Los Angeles, California, has announced development of a fluid-driven power swivel that permits light rotating jobs to be carried out on a rig without need for installing kelly, rotary table, or other heavy equipment. Typical applications include internal cutting and fishing jobs, drilling out sand or cement bridges, scraping liners, drilling out cement in tubing, and many other similar operations where sensitive control is essential and only limited torque is required.

Basically, the Baash-Ross Power Swivel consists of three units—the swivel itself, the control unit, and the power unit. The power unit consists of a compact gasoline engine that drives a fluid pump, thus generating hydraulic pressure that is circulated to the swivel by means of flexible hose connections. The control unit can be mounted wherever convenient and permits instant starting, stopping, and reversing the direction of rotation of the swivel. A pressure gauge incorporated in the control unit gives accurate and direct indication of the amount of torque being developed in the rotating string so that complete control is maintained at all times.

The swivel unit can be suspended in the derrick with regular tubing elevators, and torque arms extend radially for anchoring the non-rotating portion of the swivel to the derrick legs so that torque can be developed without twisting the supporting lines. The swivel and fluid-drive unit are integrally combined into one compact housing and the lower end of the swivel connects directly to the run-in string. No kelly or rotary table is needed. The power swivel is designed to deliver maximum efficiency at a speed of approximately 17 rpm.

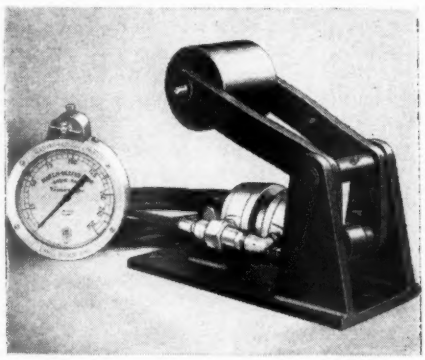
(6) Torque gauge

The Hydro-Mech assembly of Martin-Decker Corporation, Long Beach, California, consists of a pressure unit gauge for installation at the driller's position and connecting high pressure flexible hose. A lever arm carrying a steel idler wheel supported by an "O" ring packed piston and cylinder forms the chain idler assembly.

The chain idler assembly is installed under the tight side of the rotary chain, where by pumping more or less fluid into the cylinder, the idler roller is raised or lowered to deflect the chain (in the same manner that the Martin-Decker weight indicator diaphragm deflects the dead line).

The tendency for the chain to straighten under load exerts force against the roller, which is supported through the lever by the fluid in the cylinder.

Pressure developed within the cylinder varies according to the force exerted on the roller by the deflected chain. Pressure variations are transmitted through the high pressure hose to the gauge placed in the drilling control panel at the driller's station.



The idler roller runs on two tapered, grease packed bearings. Grease is retained by grease retainers, which keep grease in and mud and abrasive material out. Grease fittitng is provided.

The hose is connected to the Hydro-Mech pressure assembly by means of a Martin-Decker developed self-sealing coupling that automatically seals fluid in the cylinder and hose when disconnected. Therefore, no filling or pumping is required when installed or dismantled.

When the idler assembly is to be moved, the self-sealing coupling is disconnected, and the hose carried in the panel box. When reinstalled, the self-sealing coupling is connected and pressure contact, without loss of fluid, is reestablished.

Recorder for the Hydro-Mech Torque Gauge is optional.

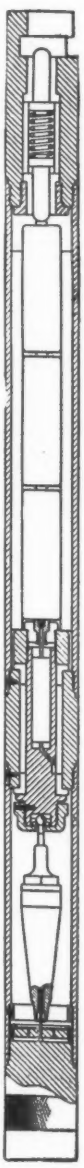
Torque readings by the Hydro-Mech Torque Gauge are more direct than through manifold pressure changes and are thus more sensitive, the manufacturer asserts.

The Hydro-Mech fills the torque gauge need for diesel powered rigs, it is said further.

Twin Aids in Your Drilling Operations

by SPERRY-SUN

The E-C INCLINOMETER



It Double-Checks!

The E-C Inclinometer is not only self-checking, but also has the "Double Checking" **feature.** In wire line operation, the instrument is run into the well to the predetermined depth where a record is made, it is then raised approximately 100', and again lowered to the previous depth. Another record is then obtained, thus "Double Checking" the angle of Inclination at that point.

Similarly, when the E-C is Go-Deviled, a record is made when it reaches the bottom of the hole. The Drill Pipe is then turned and again brought to rest. A second record is then made by the E-C thus "Double Checking" the angle of inclination at this point. This "Double Check" takes only an extra couple of minutes. This cannot be done with other instruments. It gives you positive information regarding your well, and **it saves rig time** for you.

The S-S NON-MAGNETIC DRILL DOLLAR

Means great savings in rig time!

More accurate records!

Less Hazardous Operation!

A great saving of rig time, more accurate records and less hazardous operation are affected by employing the S-S Drill Collar. It is inserted immediately above the drill bit, and is made with proper seating arrangement to center the directional single shot surveying instrument.

Any operator will recognize its particular advantages when used in directional controlled drilling. The statement that it is made of "K" **Monel metal is sufficient** evidence of its strength and resistance to wear. Made in standard sizes. Available on a rental or outright sales basis.

Other Sperry-Sun Instruments and Services

SURWEL Clinograph, SYFO Clinograph, K-K Whipstock and Retrieving Sub., M-M-D Bottom Hole Orientation, Polar Core Orientation

SPERRY-SUN WELL SURVEYING COMPANY

Offices: Philadelphia, Pa.; Houston, Corpus Christi, Falfurrias, Marshall, Odessa, Texas; Lafayette, La.; Long Beach, Bakersfield, Calif.; Oklahoma City, Okla., Maulden Oil Field Services; Casper, Wyo.

(7) Log-O-Graf

Warren Automatic Tool Company, Houston, Texas, manufacturers and distributors of the familiar "Mud-O-Graf" (mud weight recorder) and "Pit-O-Graf" (pit level recorder) and other specialties, announces production of the newly developed "Log-O-Graf."

This new instrument provides an entirely automatic and continuous record of the rate of penetration of the drilling bit in the formation. The strip-type chart is graduated in inches and tenths of an inch to conform to an electrical log. No replotting is necessary, for all changes in lithology in the form of a curve are recorded as drilled. This information that is indicative of the degree of porosity and permeability of formations is im-

mediately available for correlation. The geologist has subsurface control of the well while actual drilling is in progress.

According to the manufacturer, the Log-O-Graf is easy to install and operate. The instrument is mounted on the derrick floor where it can be constantly observed by the driller. The method employed makes use of a small steel line, which is attached to the swivel and is threaded over a sheave just below the crown block, then to the driving sheave of the instrument, then to a sheave below the thribble board where it is connected to a dolly that rides up and down a guy wire of the derrick.

The Log-O-Graf is available on a rental basis in domestic fields and may be purchased outright for export.

(8) Magnetic probe

The Magicbar magnetic probe has been designed to meet the universal requirement for a convenient, powerful magnetic probe adapted to scores of industrial, first aid, and household uses, according to the manufacturer, Eljay Enterprises, Newark, New Jersey. The probe consists of a streamlined housing of polished plastic containing a powerful magnet that can be expelled from and retracted into the housing much like a mechanical pencil. A pocket clip is provided so the probe may be carried in the pocket.

In addition to employing a permanent magnet made of the most powerful alloy known to science the probe incorporates an exclusive feature permitting automatic adjustment of the effective strength of the magnetic field. The magnet can be expelled from the housing by simply turning a convenient knob. The strength of the magnet depends upon the extent to which the magnet is expelled. The magnetic strength is a maximum when the magnet is fully extended and a minimum when the magnet is fully retracted. This feature is of significant value in many uses of the device.

Industrial uses: Removal of magnetic particles from the operating area of electrical instruments and other delicate mechanisms in which such foreign particles would interfere with the operation of the device. Assemblers and inspectors will find the probe useful to test coated surfaces to determine whether the underlying material is magnetic; to remove sharp iron objects from storage bins; to retrieve magnetic items such as nails, screws, and washers from sweepings, holes, etc.

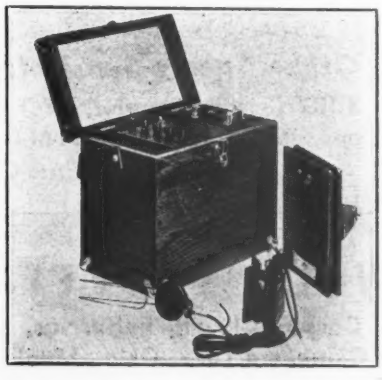
First aid station use: Plant first aid stations will find the probe a most useful tool for the removal of steel splinters from employes eyes and skin, it is stated. The adjustable magnetic strength feature makes it possible for the nurse or doctor properly to orient the splinter for extraction without painful rupture of the tissues.

(9) Pipe locator

Combination of factors for determining the precise location and depth of buried pipe and cable with the Stewart Cable Tester is an important improvement announced by W. C. Dillon and Company, Inc., 5410 West Harrison Street, Chicago 44, Illinois. The new product is called The Stewart Cable Tester and Locator Combined.

To the location of shorts, crosses, grounds, and wet spots the new instrument now adds finding ability of most practicable service. In simple operation it tells just where cable or pipe is buried, and just how deep. It finds old cable or pipe laid many years ago on which installation records have been lost or forgotten.

It is especially valuable for checking depth of cable at river crossings. It determines whether or not a service pipe



is below the frost line in lowering or regrading thoroughfare.

It is supplied with detector coil and neutral exploring coil. Built-in level in coil enables operator to maintain absolute accuracy.

The unit is ruggedly built, easily portable, compactly encased for rough use and weather. Size: 12½ in. by 7¼ in. by 11 in. high. Weight: Approximately 22 lb, including head phones and neutral exploring coil, and fish scale exploring coil.

(10) Aldrich pumps

The inverted septuplex and nonuplex pumps are an addition to the Aldrich line of inverted triplex and quintuplex pumps. With these additions the line now covers pumping units from 15 to 2400 hp. Rather than build enlarged versions of the quintuplex for the larger horsepower range, standard quintuplex parts were used to construct assemblies of more pumping elements—7 and 9, respectively, for the septuplex and nonuplex.

Due to the method of lubrication in these pumps, they are adaptable to higher speed than any previous design reciprocating pump, the manufacturer states. For this reason they may be engine type driven by a synchronous motor mounted directly on the pump crankshaft, or, in the larger sizes, direct coupled to engines having speeds from 225 to 275 rpm. In sizes 800 hp or less, the pumps are designed to incorporate built-in gearing for direct coupling to pinion-shaft for use with either high speed motor or engine drive.

For oil-field service these pumps are designed to carry ring joint construction on valve covers, discharge connections, and blank flange connections, together with stuffingbox linings to accommodate plungers of various diameters.

The Aldrich Pump Company, Allentown, Pennsylvania, is the manufacturer.

(11) Le Roi Airmaster

The newest compressor to be announced is the "85" Airmaster manufactured by Le Roi Company, Milwaukee, Wisconsin. Shown originally to its distributors during a recent sales meeting, it has now been placed into production schedules.

The power plant is the Le Roi model D201 valve-in-head engine with replaceable cylinder sleeves, precision bearings, pressure lubrication, and magneto ignition.

The compressor, built integrally into the engine block is liquid cooled and also has pressure lubrication, replaceable cylinder sleeves, and precision bearings. Cylinder head and compressor valves are identical to those of the entire Airmaster series of portables.

Compressor is regulated by the Le Roi patented Econotrol, controlling compressor operation automatically according to the demand for air.

Electric starting and the exclusive electric hourmeter are supplied as standard equipment.

ON THE JOB COMPLETE THE JOB FASTER WITH IDECO RAMBLER RIGS

Here's the answer to lower cost operation . . . whether it's drilling, work over or servicing!

The Ideco Rambler Rig is a complete, ready-for-action rig on wheels . . . speedy to move . . . speedy to erect . . . speedy to operate. It combines two star performers—the Ideco Hydrair fluid-driven, air-clutched hoist with its power plant, and the Ideco Kwik-Lift telescoping mast. It mounts on either truck or trailer.

Rambler Rigs speed hoisting as much as 30% because the Hydraulic Torque Converter automatically selects the fastest speed at which a given load can be lifted . . . gives maximum speed for raising empty block . . . maximum pull for coming out of the hole . . . and delivers more horsepower at the hook.

Get full details on this cost-cutting rig today! Send for Bulletin RR-47.

- **Transported ready-rigged... into action in minutes!**
- **Fluid power . . . flexible control . . . plus air-clutch smoothness.**
- **Faster hook speeds under all loads; maximum pull . . . automatically.**

INTERNATIONAL DERRICK & EQUIPMENT COMPANY

Sales Headquarters: Dallas, Texas

Export Offices: Dallas, New York, Torrance

Sales Offices, Stores and Distributors everywhere

ONE OF THE DRESSER INDUSTRIES

(12) Impact tool

Ingersoll-Rand Company, New York, New York, announces a new universal electric, all-purpose impact tool. Using standard attachments, it will apply and remove nuts, drill, ream, tap, drive, and remove screws; drive and remove studs; extract broken cap screws and studs; run wire brushes; do hole saw work; drill brick and masonry, and drive wood augers.

This new machine is designated as Size 4U. It weighs only 6½ lb, has an overall length of 10½ in., a free speed of 2000 rpm, and delivers 1900 rotary impacts per minute under load. It is powered with a specially designed reversible, universal, electric motor (3 amp) that operates on 110 volt, ac-dc current.

The impact tool runs just as any conventional electric tool until the resistance to spindle rotation reaches a certain amount. Then a patented mechanism converts the power of the motor into "rotary impacts," which exert a powerful turning effect.

(13) Anglevel

A combination level and angle indicator is announced by the R-D Company, Flint, Michigan. The equipment is known as the Anglevel and is usable from all four surfaces with vials visible in any position with the added features of quickly determining angles, slopes, pitches, and inclines to a high degree of accuracy. Numerals on dial facilitate finding the relation of angular surfaces to horizontal and vertical surfaces.

The Anglevel is a refinement and improvement over conventional levels, for it offers everything that the craftsman has now, plus true and rapid measurement obtained usually through the use of protractors or other expensive precision instruments, according to the manufacturer.

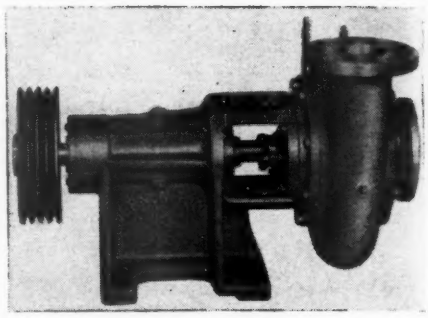
The Anglevel is equipped with retainers into which vials (2 horizontal, 2 vertical) are placed and give instant readings in these positions. Retainers can be inserted, adjusted, and positively locked into position in three minutes or less and are replacable at a very nominal cost, it is stated.

The Anglevel is equipped with dial indicator that is sensitive and exact. The dial is made of clear, unbreakable plastic, calibrated in degrees (0-360) and graduated in such a manner as to make it practical for use by the most particular and painstaking craftsman, according to the makers.

The frame is heat-treated aluminum, 16 in long, 3 in wide, and ¾ in. thick. Weight: Approximately 1 lb 8 oz.

(14) New centrifugal pump

Vernon Tool Company, Ltd., Alahambra, California, announces a new centrifugal pump built specifically for handling rotary drilling mud and other particularly abrasive fluids. This pump incorporates numerous features designed



to withstand wear caused by sand, rocks, shale, and other solids commonly present in oil-field operations.

The Vernon centrifugal pump was originally intended solely for use with the Vernon-Corwin rotary mud desander. Its outstanding performance, however, has disclosed other oil-field applications including mud transferal and mud loading, sump and pit cleanout work, and as booster pump for regular rig mud pumps.

This Vernon pump is a heavy-duty, slow speed centrifugal and is adaptable to either V-belt or direct drive.

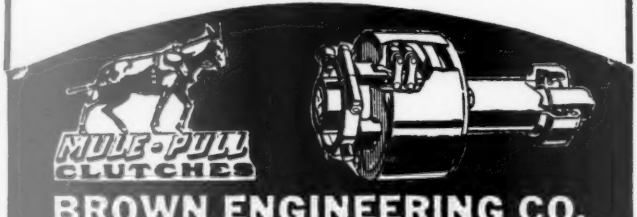
(15) Acid resistant valve

Farris Engineering Corporation, 481 Commercial Avenue, Palisades Park, New Jersey, has developed a line of corrosion resistant safety and relief valves for use principally in the process and petroleum industries.

Haynes Stellite Company "Hastelloy-

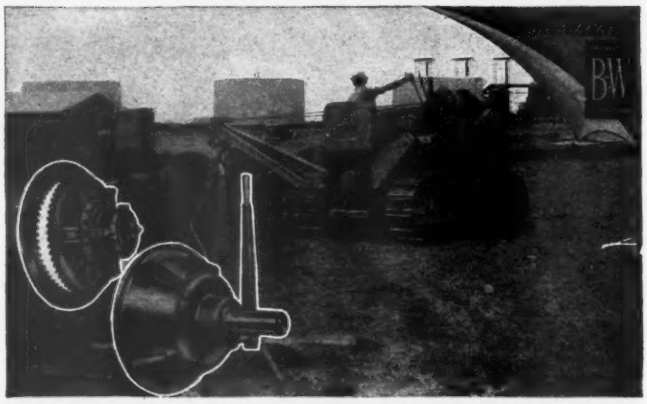
SAVES OIL
SAVES LABOR
SAVES POWER

Every purchase dollar you spend for MULE-PULL Clutches is repeatedly paid back to you by the several economies they effect. By employing rolling contact, MULE-PULL Clutches are given a simplicity of design that produces high efficiency, long life and high power capacity. The Anti-Friction Roller Toggles which actuate these Clutches require no lubrication and develop a powerful pull that promotes production and produces profits. The pulley-carrying sleeves have Ring-Oiling lubrication that is copious without waste and is proportional to the speed; one filling of oil lasts from 30 to 90 days; scored shafting is eliminated, and the time spent by your Oil Man is reduced since your Clutches and Ring-Oiling Shaft Hangers can both be oiled at the same time. Send for interesting Bulletin No. 25-A.



BROWN ENGINEERING CO.
133 NORTH 3RD ST. READING, PENNA.

ROCKFORD



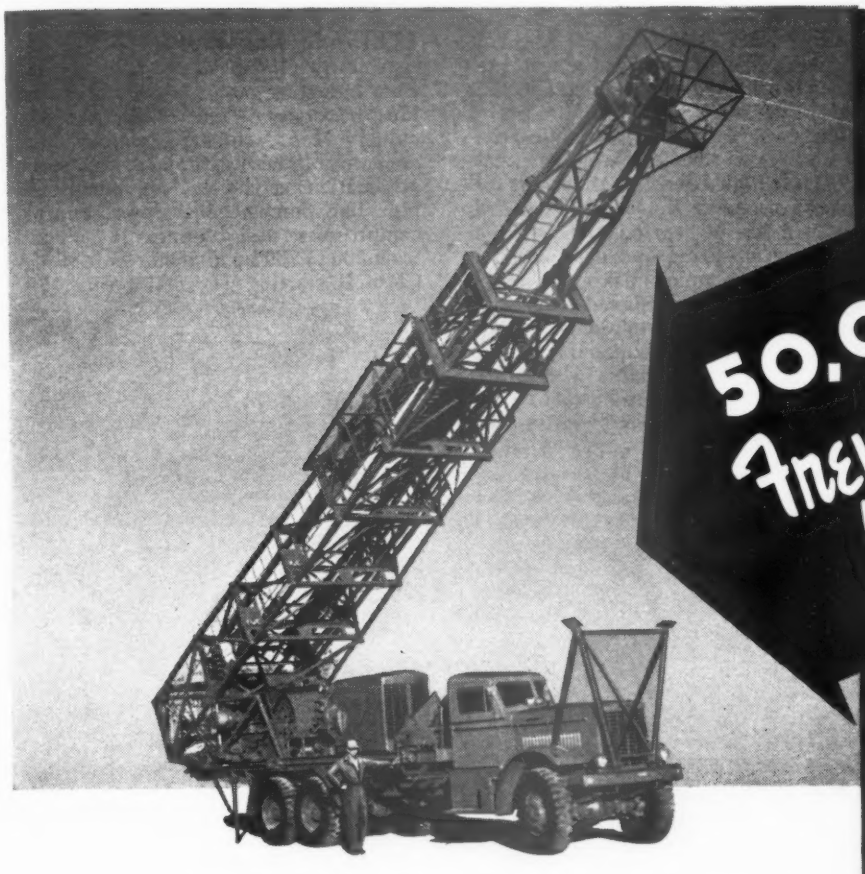
POWER TAKE-OFFS

SELF CONTAINED UNIT
WIDE RANGE OF SIZES
CONSERVATIVE RATING
ROLLER BEARINGS
FINE ADJUSTMENT *
ACCURATE BALANCE
S.A.E. DIMENSIONS

* Fine adjustments of ROCKFORD POWER TAKE-OFFS are maintained by simple, positive locking means, located near the outer diameter of the clutch. The lock is readily accessible, through a hand-hole in the bell housing or cover.

SEND FOR THIS HANDY BULLETIN
Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD CLUTCH DIVISION BORG-WARNER
1303 Eighteenth Avenue, Rockford, Illinois, U.S.A.



50,000,000 Frenchmen can't be wrong!

It's an old saying that "50,000,000 Frenchmen can't be wrong," so when a French Government sponsored gas company was seeking truck-mounted rotary drilling equipment for extremely deep geophysical research in the Toulouse area of southern France, they naturally selected an Oshkosh heavy duty truck on which to mount the rig.

This equipment, mounted on a W-1602-BDH Oshkosh Truck (shown above and below) is one of the largest truck-mounted rotarys ever built and the truck engine and auxiliary engine, both of which may be used for driving the unit over the road and for operating the rig, are diesels and develop in excess of 350 hp.

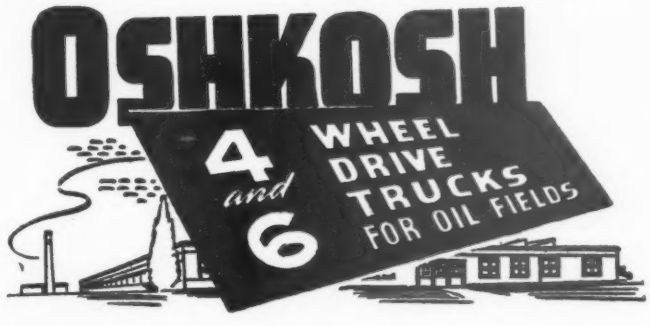
It is significant that when trucks are sought to move and operate giant equipment, Oshkosh Trucks have such wide acceptance. If you have a problem requiring trucks that can move and operate the heaviest equipment, it is only logical that you should buy OSHKOSH TRUCKS.

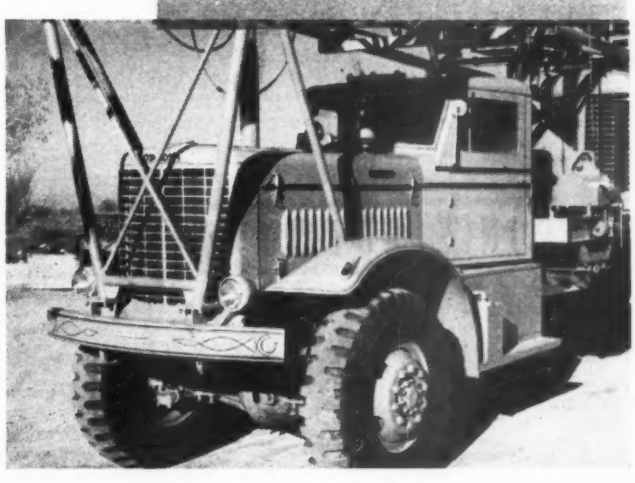
OSHKOSH FEATURES:

- ALL WHEEL DRIVE
- HYDRAULIC POWER STEER
- MAXIMUM MANEUVERABILITY
- RUGGED TRANSMISSIONS
- STURDY FRAMES AND AXLES
- POWERFUL ENGINE
- HYDRAULIC COUPLING
- HEAVY DUTY, OVER SIZE INDUSTRIAL TYPE RADIATOR
- AIR ACTUATED BRAKES

Write for Literature on our line of Oil Field Trucks

OSHKOSH MOTOR TRUCK, INC.
OSHKOSH, WISCONSIN
CABLE ADDRESS: "OSHMOTOR" OSHKOSH





C" is used for the inserted nozzle and the valve disk and, in certain models, for the complete valve body. This alloy is a hard, tough, corrosion resistant, nickel-iron alloy containing molybdenum, silicon, and copper, which is proof against the corrosive action of any of the acids or caustics normally handled on a commercial scale.

All working parts of the valve are completely isolated behind a vapor proof "FarriSeal" curtain. This protective seal is a flexible material attached to the disk at one end and the flanged disk guide at the other, in such a way to completely isolate the working parts from the gas or vapor within the body of the valve. The material of the seal may be of either rubber, Neoprene, or any flexible metal designed to withstand the action of specific acids or caustics.

These two design characteristics, coupled with the advantages of the nozzle throat, the high disk lift that permits full capacity discharge, the long low-stressed, protected loading spring, the precision alignment of spring and disk, and the top-loaded free-acting disk guide result in a line of valves designed to provide maximum service with minimum maintenance, according to the manufacturer.

The valves are available with flange connections in sizes from ½ in. to 2 in., with screwed connections ½ in. to 1 in.

Class 411
Explosion Proof
LIGHTING PANEL

Photograph of
16 Circuit Enclosure

Has the following outstanding features:

- Compact in size, yet having ample wiring space.
- Large number of conduit opening combinations.
- Available in many single pole circuit combinations.
- Additional breakers can be readily added in field.
- Corrosion Resisting operating shafts and mechanism.
- Uses Quick-Lag Circuit Breakers, providing:
  (1) Faster opening action on short circuits.
  (2) Full Time Delay on Overloads.
- Surface or Flush Mountings.
- Two size Enclosures, 8 and 16 Circuit.

Provides branch circuit protection for electrical circuits, especially designed for Class1, Group D Hazardous Locations and can also be used in Class 2, Group E, F and G.

This panel was designed to incorporate many of the features that field men and application engineers requested, such as a compact unit with ample wiring space. The complete breaker and bus assembly can be readily removed, allowing full enclosure space for pulling wires.

The Class 411 Panel utilizes the well known Quick-Lag Circuit Breaker preventing unnecessary interruptions on harmless overloads and providing fast opening action on short circuit. Will interrupt short circuit currents as great as 5,000 amperes within 1/240 of a second.

Complete specifications, dimension details and conduit arrangements together with prices will be furnished promptly on your request.

NELSON ELECTRIC MANUFACTURING CO.

217 North Detroit — TULSA, OKLAHOMA — Telephone 2-5131

MANUFACTURERS OF:

Explosion Proof Motor Controls
Junction Boxes and Enclosures
Circuit Breakers and Lighting Panels
Oil Field Motor Controls
Automatic Pipe Line Sampling Devices
Cathodic Protection Equipment
Switchboards
Instrument and Control Panels
Unit Substations

(16) Induction motor

A newly announced two-pole squirrel-cage induction motor is an addition to the "heavy-duty" line of Electric Machinery Manufacturing Company, Minneapolis, Minnesota, for such high-speed applications as boiler feed pumps, oil pipe line pumps, centrifugal pumps, compressors, and blowers. It is rated from 200 to 700 hp at 3600 rpm; NEMA Class B starting (normal torque, low

current), favorable for across-the-line starting, and is of drip-proof construction, with fabricated steel frame.

The motor is engineered to meet the exacting requirements of high-speed service: (1) Kolene Process centrifugally-cast bearing sleeves, (2) pressure-lubricated bearings available, (3) split bearing brackets (doweled) permit easy access to bearings, (4) windage noise lessened by design to avoid abrupt acceleration of air, (5) phos-copper braze-welded cage winding.

(17) New electrode

A new electrode for hard-surfacing applications where resistance to impact, wear, and abrasion is required has been announced by the Electric Welding Division of the General Electric Company. Designated Type W-94, the new electrode will work-harden to more than 50 Rockwell C. It operates on a-c or d-c reverse polarity.

W-94 is available in 14-in. lengths, with diameters of ¼, 3/16, 5/32, and ⅛ in. It is packaged in 50-lb standard packages, and can be shipped from stock.

(18) Silver solder

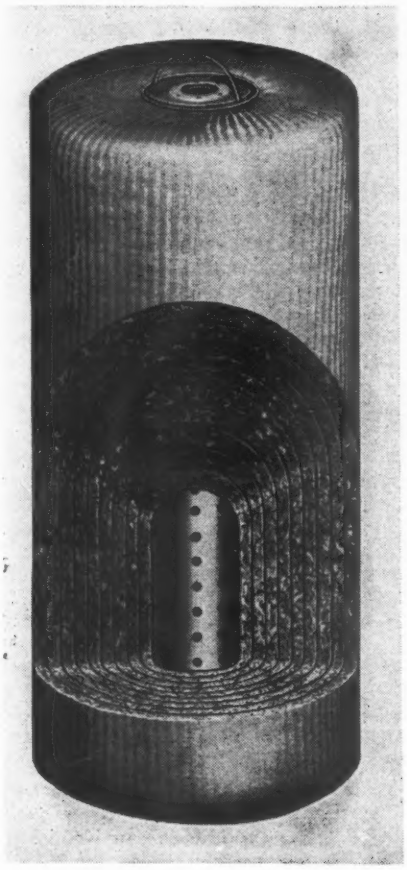
All-State Welding Alloys Company, Inc., 96 West Post Road, White Plains, New York, announces the immediate availability of a new silver solder that has the advantages of high capillary action, exceptional tensile strength, and good appearance after brazing. It is also particularly economical, for its silver content is 20 per cent, a proportion that has been found to give higher tensile strength than silver solders with a greater content of silver. As it is so economical, it also makes possible many jobs that were not previously done with silver because of the prohibitive price. This alloy has a melting temperature of 1430 F and shear strength of 145,000 psi. It is particularly suitable for the brazing of carbide tips to steel shanks and for the

fabrication of light steel parts. It is also recommended for use on steel, brass, copper, stainless steel, and inconel. It is available in wire, strip, or rings. This alloy, known as All-State No. 120 High-Strength Silver Solder, is used with All-State No. 103 flux.

(19) Oil filter element

Standard equipment for all types of lubricating systems is the new Engine-Life oil filter element manufactured by Engine-Life Products Corporation, El Monte, California.

Engine-Life replacement filters consist of lint-free textiles wrapped in a closely knit muslin, pressure wound in convolutions around a perforated metal core, and covered with a heavy tubing or muslin jacket. The horizontal flow of oil from outside to inside through the



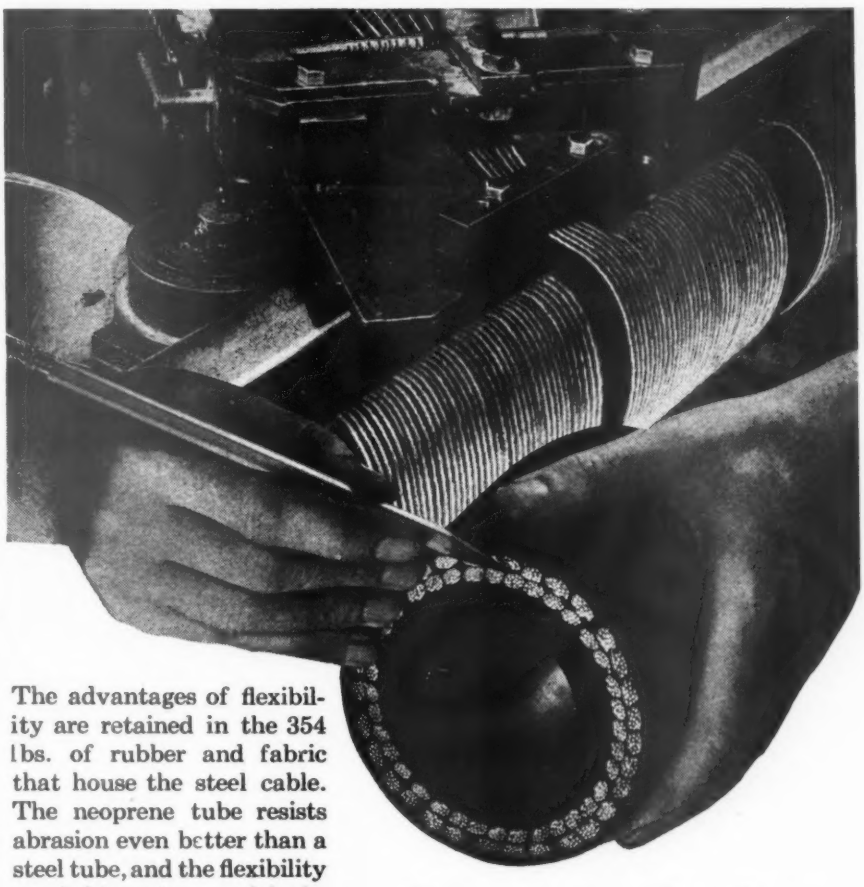
laminated construction materially increases dirt and sludge removal. As elements absorb contaminants they expand, allowing greater dirt storage capacity and a higher saturation point than elements in metal containers, it is stated.

Engine-Life filters are used exclusively in the automotive trade, in diesel electric plants, in industrial applications for power plants, in machine shops for coolants and lubricating oils, in oil fields and pipe line equipment, for maintaining construction and mining equipment, for marine engines and pumps, farm power equipment, and for hundreds of applications where dirt, grime and moisture in oil can result in a complete breakdown of engines.

This "Rubber" Hose is 67% steel!

716 lbs. of steel for strength—354 lbs. o frubber and fabric for flexibility—that's the efficient make up of Thermoid Powerflex Rotary Hose, built to go "all the way" in deep hole drilling!

Thirty-three *miles* of high tensile steel wire, formed into 9300 ft. of cable, and precision wrapped—and counter-wrapped, gives each length of Thermoid Powerflex Rotary Hose strength to withstand the highest pressures that may develop under any condition.



The advantages of flexibility are retained in the 354 lbs. of rubber and fabric that house the steel cable. The neoprene tube resists abrasion even better than a steel tube, and the flexibility needed for rotary work is obtained in a single, unbroken, free-flowing length of hose.

Thermoid Powerflex Rotary Hose has the strength *of steel— and the* flexibility *of rubber!*

Thermoid Products

Automotive • Industrial
Oil Field • Textile

Thermoid Company, Trenton, N. J., U. S. A.

Warehouses in Houston, Los Angeles, Wabash

(20) Pulsing drive

The pulsing drive is a new device for controlling electrical motors when accurate positioning is important. The drive responds to the operation of a single knob. When this knob is rotated in one direction, the Pulsing Drive closes selectively one of two circuits for very short periods of time repeated at a rate dependent upon the speed of the knob rotation.

A slow, clockwise rotation of the control knob causes a series of short electrical pulses to be applied to the motor-winding, corresponding to the desired direction of rotation, and results in a corresponding motor motion in small increments. Slow counter-clockwise rotation of the knob causes reverse motor rotation in small increments.

The time period—basic pulse duration—is easily adjustable within a wide range to suit local conditions so that a motor-driven load can be very accurately positioned.

When the rate of pulsation increases, due to faster knob rotation, a point is soon reached at which the pulses overlap so that the switching circuit is kept closed as long as the knob is rotated at that speed, resulting in faster, more extended, travel of the motor.

Provision is also made for continuous contact, when continuous rotation of the motor at full speed in either direction is desired.

The Pulsing Drive is a product of Yardeny Laboratories, Inc., 105 Chambers Street, New York, N. Y.

(21) Splicing compound

An oil-resistant compound for splicing electrical wire is announced by United State Rubber Company, Rockefeller Center, New York City.

The new compound is made of Neoprene rubber combined with special synthetics. It is recommended for use on any electrical circuit coming in contact with oil.

It will be distributed in the form of tape 30 ft long, ¾ in. wide and 0.030 in. thick.

(22) Core gas analyzer

Petroleum Instrument Company, 4601 Montrose Boulevard, Houston, Texas, announces a new oil-well instrument in its supersensitive, portable Core Gas Analyzer, which, according to the manufacturer, is designed to provide a quick, simple, and accurate core analysis in the field.

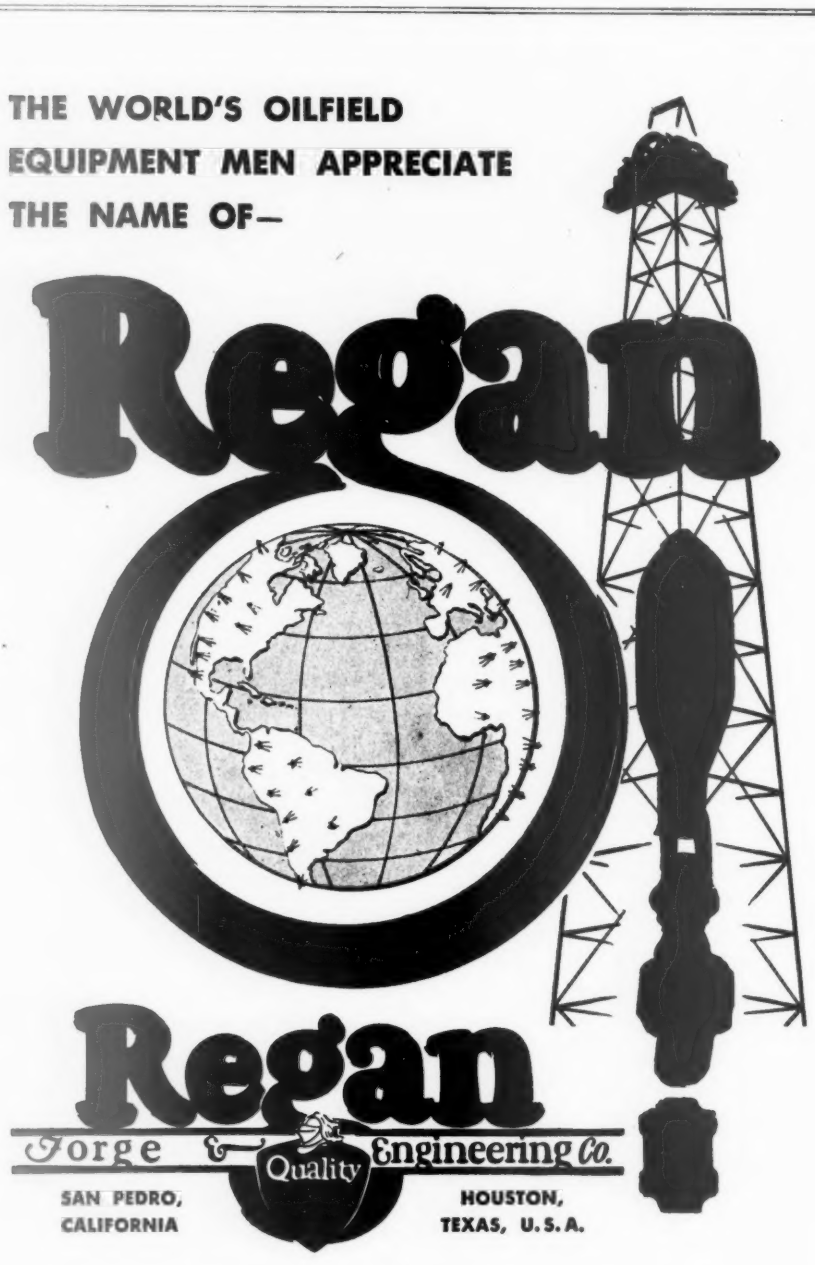
The instrument is housed in a compact, lightweight case that may be easily carried from well to well for analyses.

The Core Gas Analyzer utilizes a special extraction chamber for cutting and removing a sample from the core to be analyzed. Two such extraction chambers are supplied with the apparatus—one for small side well cores and one for conventional cores.

When the core sample is obtained from the core to be analyzed and placed in the extraction chamber, even a minute quantity of gas present is measured and immediately indicated. Even though the amount of the gas may be too small to burn openly, if there is gas present at all, it will be in sufficient quantity to create a thermal combustion effect across the sensitive platinum element of the instrument, which is used as a catalyst and which thus effects an electrical bridge circuit. The readings are taken direct from the gas volume meter of the unit.

According to the manufacturer, the Core Gas Analyzer provides a positive test for the presence of hydrocarbon gas in cores, determining the relative volume accurately and quickly. Heretofore, there has been no reliable means of making this determination in the field as it is a well known fact that methane or natural gas in a core is very difficult to detect by smelling or tasting of the core sample due to the fact that unscented natural gas is practically odorless. Thus the new instrument makes it possible for coring procedure and drillstem test points to be determined immediately at the rig with more positive results, the manufacturer asserts.

A further advantage is stated to be in the simplicity of operation of the apparatus as it requires no special skill to use it. Operators do not require complicated computations or formulae as readings are taken directly from the self-contained gas volume meter of the



EXCLUSIVE MID-CONTINENT REPRESENTATIVES: Hunt Tool Company, P. O. Box 1436, Houston, Texas
EXCLUSIVE EXPORT REPRESENTATIVES: Hunt Export Company, 19 Rector Street, New York City, N. Y. • Avda Pte. R. Saenz, Pena 832, Buenos Aires, Argentina

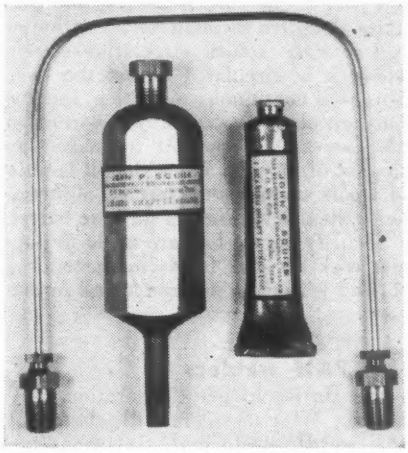
instrument. Moreover, the accuracy of the instrument eliminates all chances of error due to the "human element."

The new instrument is available on a monthly or annual rental basis in domestic fields and may be purchased outright for export. An illustrative bulletin will be sent on request.

(23) Bearing shaft lubricator

John P. Squier Measurement-Engineering Service, Dallas, Texas, announces an automatic bearing shaft lubricator for orifice meters, designed for high pressure gas measurement.

Positive action utilizes pressure drop across the orifice plate in maintaining a pressure on the lubricant slightly higher than the measured product, thus preventing any leakage and allowing free action of the differential shaft. A reverse



check valve prevents flow of lubricant to mercury chamber in case of sudden release of pressure from meter or back flow in transmission line. The entire lubricator unit is constructed for operating pressures to 5000 psi, is plated for weather protection, and provided with stainless steel tubing and connections. Special low viscosity wet lubricant is supplied with each unit. The lubricator eliminates bearing shaft trouble for periods from one to three years without attention, according to the maker.

(24) Surface controller

A new surface controller announced by Garrett Oil Tools, Longview, Texas, features simplified controls for regulating frequency and length of gas injections, injection gas pressure, and volume.

The new controller contains a high pressure regulator that obviates the necessity of purchasing a separate regulator for use on high pressure gas lines, it is stated. A simple, dependable time control clock governs the frequency of gas injections and an easily adjusted thumb screw determines the length of each injection. All controls, with the exception of the motor valve, are enclosed in a weather-tight steel hood and are easily accessible for adjustments and repairs.

An unusual feature of the controller

ATLAS may have lifted the world on his shoulders... but you don't have to be a muscle-man to handle the new CHIKSAN Non-Spin Mud Gun. It *can't* spin because centrifugal force is neutralized by the offset in the barrel of the gun. Design is simple... construction is fool-proof... flow is not restricted ...can be locked in any position for unattended service... proved by the thousands of CHIKSAN Mud Guns now in service. With the new CHIKSAN Non-Spin Mud Gun, you get *everything* in mud gun performance...at no premium in price.

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is that it may be used as a well purger during twilight periods of flowing wells. When used for this purpose, the timing mechanism is removed; it is installed later when the wells go on gas lift and the controller is used for regulating gas injection to the gas lift valves. The new controller can also be used as a pressure regulator in services other than gas lift.

(25) Feedwater controller

A new method of sensitively controlling feedwater for boilers, embodying powerful and positive magnetic action, has been developed by J. A. Campbell Company, 645 East Wardlow Road, Long Beach, California. The product, known as the Micro-Netic electric controller, weighs only 7½ lb and can be attached to a boiler to occupy a space of 3½ in. by 7½ in. for its housing and with a switch box measuring 2 in. by 4 in. by 6½ in. The Micro-Netic embodies a round ball float of monel, capable of resisting a pressure of 400 psi. This float carries a steel ring that attracts the magnets when the ring comes into their fields. Alnico permanent magnets are used, capable of lifting 100 times their own weight. A micro-switch is used. When the level of water in the boiler lowers to a predetermined point, the magnetic action opens the water line, and when the level rises to a certain point, the feed line closes automatically.

(26) Coring bit

A new type coring bit has been developed by Security Engineering Company, Inc., Whittier, California, that produces a core sample with every bit run. It can be run continuously in place of regular rock bits and does not require auxiliary equipment to be run, nor is time lost when taking a core, according to the manufacturer. When drilling, the coring bit is ordinarily run until dulled at which time a core sample of the last 3 ft of hole made is retained in the core barrel and is available for inspection when the bit is brought to the surface. It is unnecessary, however, to completely dull the bit before obtaining a core, for the bit can be pulled any time a core sample is desired. For example, a sudden change in the rate of penetration of the bit may indicate a formation from which a core is desired. After drilling into this unknown zone for a few feet, the bit can be pulled and a core recovered for identification of the formation. This is possible because this coring bit is continuously cutting a core that passes through and out of the core barrel.

This new bit gives the geologists an actual core sample of the last 3 ft of formation penetrated by the bit or a core sample at any time during the drilling operations and does not retard drilling speeds or require extra trips with special tools.

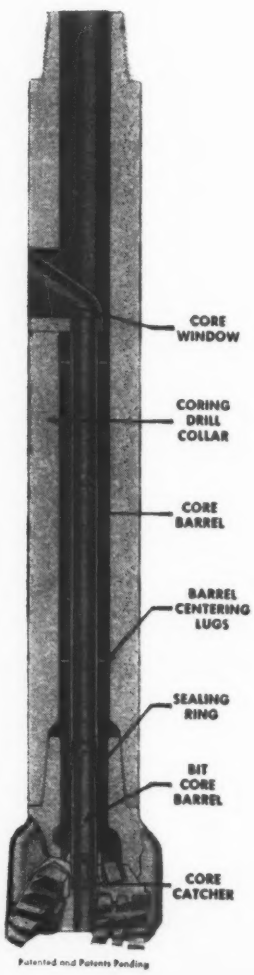
The Security coring bit assembly consists essentially of two main items: The coring bit and the coring drill collar. Each of these items is a self-contained unit without loose or protruding parts and they are easily assembled in the same way as a rock bit is made up to a drill collar.

The Security coring bit is a modified Security rock bit with the same large bearings, heavy construction, and tooth patterns. The bit contains a fixed, short core barrel that extends from the core opening in the bridge to the end of the tool joint pin on the bit. This short core barrel contains a spring type floating core catcher that is retained within the barrel and is not a loose part of the assembly.

The coring drill collar has an outside diameter and bore the same as the standard tool joint connections for the bit size. It is produced with a tool joint pin up and box down and is generally supplied 52 in. long from shoulder to shoulder. This drill collar retains the core barrel, which is centrally situated within the bore and is threaded into the core breaker cage, near the top of the drill collar. The core breaker cage is a fixed part of the drill collar and is sealed off from the downward mud stream within the collar. This core breaker cage forms a lateral opening or core window between the core barrel and the space between the drill collar and the walls of the hole. The lower end of the core barrel has a socket connection that slips over the short, fixed section of core barrel in the bit. This forms a continuous core tube when the bit is made up to the drill collar.

In operation, as drilling progresses, the core enters the core barrel until it reaches the core breaker cage. Here, the top part of the core is broken into particles, deflected through the core window and into the return circulation stream where it is circulated out of the hole. This is a continuous operation and the constant deflection of the top portion of the core allows the bit to make any amount of footage. When the bit is pulled, a core sample of the last 3 ft of formation drilled is retained in the core barrel.

Security coring bits are made in popular rock bit sizes from 7⅝ in. to 12¼ in., and with tooth designs for all formations.



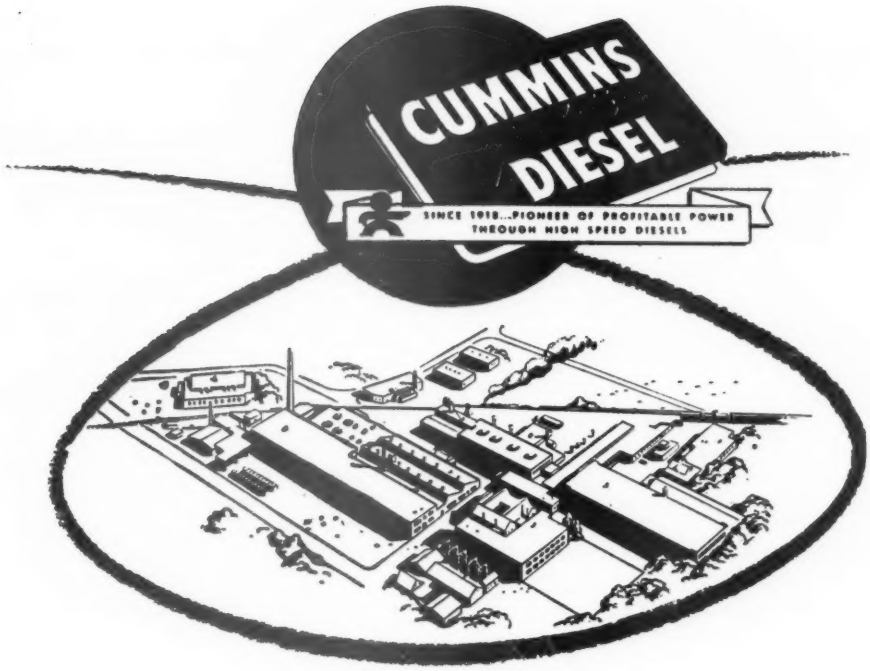
(27) P&H welders

The Harnischfeger Corporation, Milwaukee, Wisconsin, manufacturer of P&H welding and materials handling equipment, announces a complete new line of a-c arc welders.

Designed and built by P&H, the welders offer a number of unusual features. All models are supplied with P&H "Dial-lectric" Control. This simplified control entirely eliminates the need for moving coils or cores, worm gears, sprockets and chain, or lever adjustments, it is stated. It is said by P&H that there isn't a single moving part in the entire machine. Without cranks or plug-in stations, current selection is made simply by turning a single dial, which requires but a three-quarter turn to cover the full welding range of the machine, from minimum to maximum capacity.

P&H "Dial-lectric" design makes striking the arc easy and instantaneous. The need for added or auxiliary current boosters is eliminated.

All industrial models of this new P&H series are designed for remote control. This added value feature is made possible by a removable control dial. This provides a current amperage adjustment at the job for manual or automatic welding. Another improvement of these welders is the high-low welding range. Indicated on the "Dial-lectric" control dial are two separate ranges, a high for general-purpose welding and another for light-gauge welding. The new P&H a-c arc welders are offered in intermittent industrial and heavy-duty models, ranging up to 625 amp.



THIS FACTORY IS TOO SMALL

To Completely Satisfy Present Unprecedented User Demand

EVEN THOUGH . . . since the end of the war . . . Cummins have:

- spent three million dollars ($3,000,000) expanding their plant;
- increased floor space forty-four and eight-tenths per cent (44.8%).

BUT . . . this factory IS large enough:

- to build most of the Diesel Engines for the tough "premium" jobs;
- to assure users that Cummins quality and dependability will not be sacrificed to gain production volume.

CUMMINS ENGINE COMPANY, INC., COLUMBUS, INDIANA

trade literature

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(28) Larkin Cementrol equipment

Larkin Cementrol equipment is the subject of a bulletin issued by Larkin Packer Company, Inc., St. Louis, Missouri. Reprints of material published in the *Composite Catalog, The Petroleum Engineer,* and the *Oil and Gas Journal,* make available complete information on this method of cementing wells.

(29) Chains and sprocket rims

Catalog 708-B, published by The Jeffrey Manufacturing Company, Columbus, Ohio, gives complete details on chains and sprocket rims it manufactures for oil-well service.

(30) Welding fittings

Midwest Piping and Supply Company, Inc., 1450 South Second Street, St. Louis 4, Missouri, has issued Bulletin 47-1 on stainless steel welding fittings. This new bulletin includes not only the usual type catalog information, but gives suggestions for the welding of stainless steels.

(31) Lubricated plug valves

American Car and Foundry Company, 30 Church Street, New York, New York, has issued a revised 8-page pamphlet on ACF lubricated plug valves. The valves are made of steel, semi-steel, bronze, and other materials. They can be used in services involving acids, caustics, chemicals, oil, water, air, gas, etc.

(32) Six-wheel-drive trucks

The Four Wheel Drive Auto Company has issued a folder describing its line of six-wheel-drive trucks. This is bulletin No. 473. Details of construction are given and the many uses of the trucks are illustrated.

(33) Gas alarm system

A new 4-page, illustrated technical bulletin (No. 1142), which describes the Davis Multi-Point Combustible Gas Alarm System for the detection and measurement of flammable gas and or vapor air concentrations in terms of their explosibility had been issued by the Davis Emergency Equipment Company, Inc., 166 Halleck Street, Newark, New Jersey. The bulletin tells how the gas or vapor is remotely analyzed in any one or more of the 6 to 12 possible areas that can be sampled by a single multi-point system. It explains how the analyzer head placed in each area electrically signals the control cabinet as conditions change in the area being sampled (under the actual temperature conditions existing in the hazardous area).

Further description in the Bulletin covers the operation of the system when a hazardous area is contacted—how the audible and visible alarms on the control panel and in the area show which area has caused the signals—how false signals are prevented.

(34) Replaceable air filters

The application of replaceable type air filters for ventilating and air-conditioning systems is explained in an 8-page booklet issued by American Air Filter Company, Inc., 215 Central Avenue, Louisville 8, Kentucky. Descriptions and illustrations of each type filter are given, along with instructions for maintenance and detailed engineering and installation data.

(35) Type H Stirling boiler

A new bulletin has been announced by The Babcock and Wilcox Company, New York, describing the Type H Stirling boiler. This boiler is a relatively small, water-tube unit, designed primarily for installation where headroom is limited. It is particularly suitable for industrial power plants, for process steam requirements, for smaller central stations, and for heating purposes. It is also admirably adapted to the modernization of smaller power plants.

Another bulletin, "Steam Separation," has also been released by The Babcock and Wilcox Company. This literature describes B & W's equipment for steam separation in boiler drums, B & W steam scrubbers, and B & W cyclone steam separators. Operation of the equipment is shown, together with illustrations of applications in several types of boiler units.

(36) Organic chemicals

A new and revised edition of the booklet, "Physical Properties of Synthetic Organic Chemicals," has been issued by Carbide and Carbon Chemicals Corporation, New York, New York, a unit of Union Carbide and Carbon Corporation. This 12-page booklet has been designed as a condensed guide for users of organic chemicals. It contains data on applications and physical properties for more than 175 synthetic organic chemicals. The material is presented in tabular form for easy reference.

(37) Electric central power pumping

Central power pumping is one of the many applications for electric power in oil-well pumping that are described in the General Electric application manual "Oil-field Electrification," part of G-E's new program showing the benefits of increased oil-field electrification.

(38) Ideal Type S-935 slush pump

The National Supply Company, Toledo, Ohio, has issued a new bulletin on the Ideal Steam Slush Pump Type S-935 carrying eight photographs, a blueprint, performance chart, and complete specifications. This large duplex steam slush pump has been designed for ruggedness and durability. Both the fluid and steam ends are of all-steel construction for maximum strength with minimum weight. The patented "GT" piston and rod design gives a positive seal without excessive stress.

(39) Building maintenance guide

"Over the Rough Spots," the 48-page handbook published by the Stonhard Company, Philadelphia, Pennsylvania, provides the answers to more than a hundred problems inherent in the maintenance and construction of all types of industrial buildings. Packed with information about floors, walls, foundations, roofs, etc., this practical booklet has been designed as a guide for building owners and operators in obtaining economical, serviceable maintenance.

Containing information useful to organizations in all industries, "Over the Rough Spots," in addition, includes pages dealing with special problems of railroads, mines, utilities, etc.

(40) Pedrifugal pumps

A new bulletin telling of the operating and construction features of its new line of "Pedrifugal" pedestal type centrifugal pumps has been released by the Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin.

According to the bulletin, five sizes of this versatile pump handle all general pumping requirements up to 500 gpm and up to 100-ft head.

In addition to diagraming nine construction features that make for low cost and efficient operation, the bulletin carries pump, motor, and Texrope drive selection table to permit correct selection of pump size, motor operating speed, and Texrope drive to give the capacity desired. Also included are standard dimension tables of the "Pedrifugal" pump, which is stocked and sold with or without motors.

The "Pedrifugal" can be powered by electric motor or gasoline engine. If desired, pump, steel base, Allis-Chalmers motor, and Texrope V-belt equipment can be supplied as a unit.

(41) Booklet on hydrogenation

A new booklet on hydrogenation has been published by the Hooker Electrochemical Company, Niagara Falls, New York. This Bulletin No. 8 discusses the research and developmental work that Hooker is prepared to do, the facilities for both high pressure and low pressure hydrogenation, the types of hydrogenation reactions Hooker is doing, and the technical service available.

(42) Parsons 200 pipeline trenchliner

A new liberally illustrated 8-page bulletin has been issued by the Parsons Company, Newton, Iowa, on the Parsons 200 Pipeline Trenchliner. Thirty photos with complete information explain how cross-country pipe line jobs go through on schedule when Parsons 200 Trenchliner sets the pace for the pipe gang. Special working advantages includes 50 speeds to 20 fpm, and three special features that prevent wheel distortion. Complete specifications and drawing of power flow are included.

the Petroleum Engineer's CONTINUOUS TABLES

a daily reference for operating men

INSTALLMENT No. 122

A valuable and regular feature of *The Petroleum Engineer*, the Continuous Tables, now in their eleventh year of publication, were designed to save time and effort for the technician and the practical field or plant worker. The tables have proved one of the most popular and helpful departments of *The Petroleum Engineer*. Data are presented in the simplest form available with many types of information included that are best presented by curves or nomographs when three or more variables must be considered simultaneously.

The Continuous Tables have been developed as a result of suggestions for new tables, direct contributions and improvements to existing tables by members of the petroleum and related industries, including manufacturing concerns, who are continually searching for practical information reduced by computation to tabular form readily applicable to the problems daily confronting them that might otherwise necessitate a more or less tedious calculation. These contributions and suggestions from the industry have resulted in a valuable exchange of information and data contributing to the progress of the industry as a whole.

This index will be revised monthly. The index for installments 1-12, inclusive, will be found in the May, 1938, issue; 13-24, inclusive, in the June, 1939, issue; 25-36, inclusive, in the June, 1940, issue; 37-48, inclusive, in the June, 1941, issue; 48-60, inclusive, in the June, 1942, issue; 61-72, inclusive, in the June, 1943, issue; 73-79, inclusive, in the January, 1944, issue; 80-82, inclusive, in the April, 1944, issue; 83-85, inclusive, in the July, 1944, issue; 86-88, inclusive, in the October, 1944, issue; 89-91, inclusive, in the January, 1945, issue; 92-94, inclusive, in the April, 1945, issue; 95-97, inclusive, in the July, 1945, issue; 98-100, inclusive, in the October, 1945, issue; 101-103, inclusive, in the January, 1946, issue; 104-106, inclusive, in the April, 1946, issue; 107-109, inclusive, in the July, 1946, issue; 110-112, inclusive, in the October, 1946, issue; 113-115, inclusive, in the January, 1947, issue; 116-118, inclusive, in the April, 1947, issue; 119-121, inclusive, in the July, 1947, issue.

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Toledo 3-Way Threader... lightest, smallest and easiest to operate of all 3-way tools! No. 31 threads ½" to 1" pipe, wt. 7 lb. Efficient...dependable.

Today more than ever—TOLEDO Pipe Tools are just what you need to *save labor* and *cut costs* in pipe fitting operations! These highly efficient Pipe Tools are built *right* . . . to do the job *right!*

For nearly half a century—as America has progressed from the Wright Brothers' first plane to the jet planes of today . . . and from the first Ford car to the twenty-five millionth Ford—TOLEDO leadership has meant *progress* in Pipe Tools! *Keep ahead with Toledo* . . . better performance and dependability yesterday, today and tomorrow! The Toledo Pipe Threading Machine Company, Toledo, Ohio. New York Office, No. 2 Rector Street Bldg.

RELY ON THE LEADER...

TOLEDO

FOR PRECISION PIPE TOOLS

SELECTION OF MULTI-CYLINDER GAS ENGINES FOR PUMPING OIL WELLS

To calculate the required gas engine horsepower, it is necessary to know the approximate volume of fluid to be lifted from a given depth. The horsepower may then be calculated from the following:

$$Hp = \frac{\text{depth in ft} \times b/d \times 350 \times \text{sp gr of fluid}}{33{,}000 \times 1400 \times \text{efficiency}}$$

Using 1.0 as specific gravity of fluid and assuming the total lift of fluid as the pump depth, then:

$$Hp = \frac{\text{depth in ft} \times b/d}{135{,}771 \times \text{eff.}}$$

or

$$\frac{\text{depth in ft} \times b/d}{136{,}000 \times \text{eff.}}$$

The efficiency used in the above formula is the overall efficiency from the subsurface pump to the prime mover and in general will range from 40 per cent on an average well to 70 per cent on wells with low gas-oil ratios or where large volumes of water are produced. Tubing and casing or liner size as well as gas fluid separating equipment below the pump affect the overall efficiency. Experience on wells with similar conditions and equipment will serve as a guide in estimating the efficiency of the well to be equipped with pumping unit.

Where pumping equipment is installed on a new well an estimate of the amount of fluid can be made from formation tests, bailing tests, and by comparison with similar adjacent wells where production volume is known; however, if test pumping equipment is available a production test will show the amount of fluid to be pumped and thus permit a more accurate selection of gas engine prime mover size.

Production to be expected from wells that have produced by flowing, gas lifting, etc., is usually known from potential tests and horsepower calculations can be made as shown.

When electric motors are to be replaced with gas engine the horsepower may be calculated from input power to motor, or in case of other types of prime mover replacement, such as single cylinder gas engines, steam engines, etc., a polished rod dynamometer card may be taken and horsepower calculated as follows:

$$\text{Polished rod hp} = C \frac{A}{L} \frac{(\text{spm} \times \text{length of stroke, (ft)})}{33{,}000}$$

Where:

C = dynagraph constant, lb per in. of deflection,

A = area of dynagraph card,

L = length of dynagraph card, in.

Polished rod hp for dynagraph card (Fig. 1)

$$= \frac{12{,}500 \times 1.7 \times 16 \times 4.83}{3.34 \times 33{,}000}$$

= 14.9, say 15 hp

Area of card 1.7 sq in. Dynagraph constant 12,500 lb per in. of deflection.

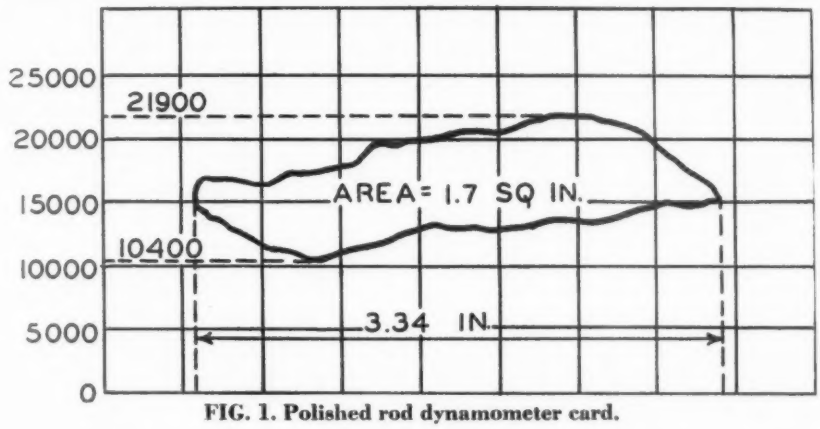


FIG. 1. Polished rod dynamometer card.

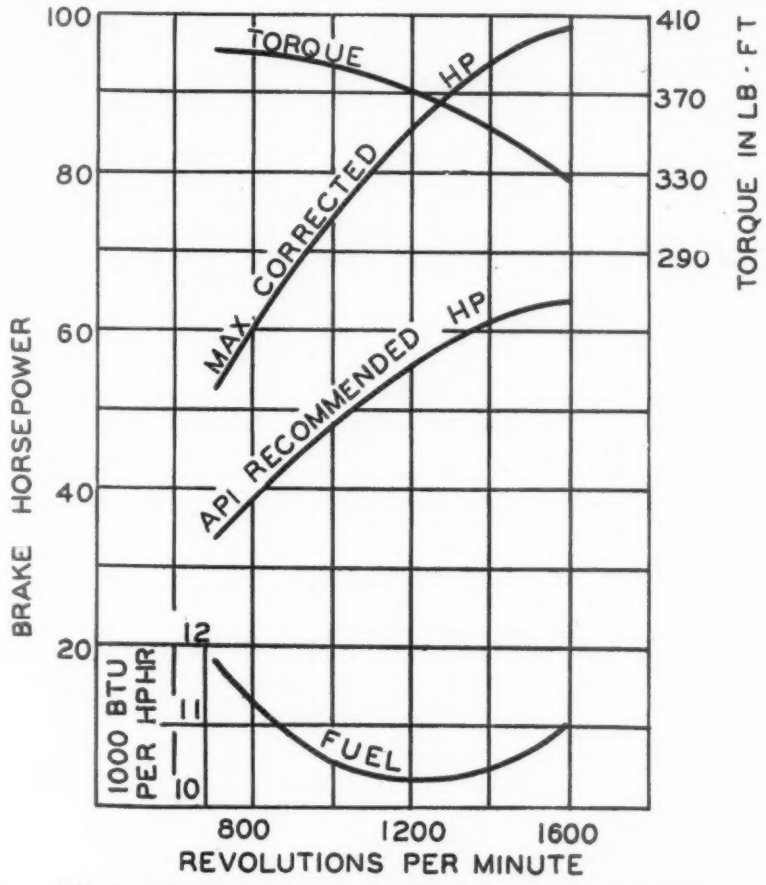


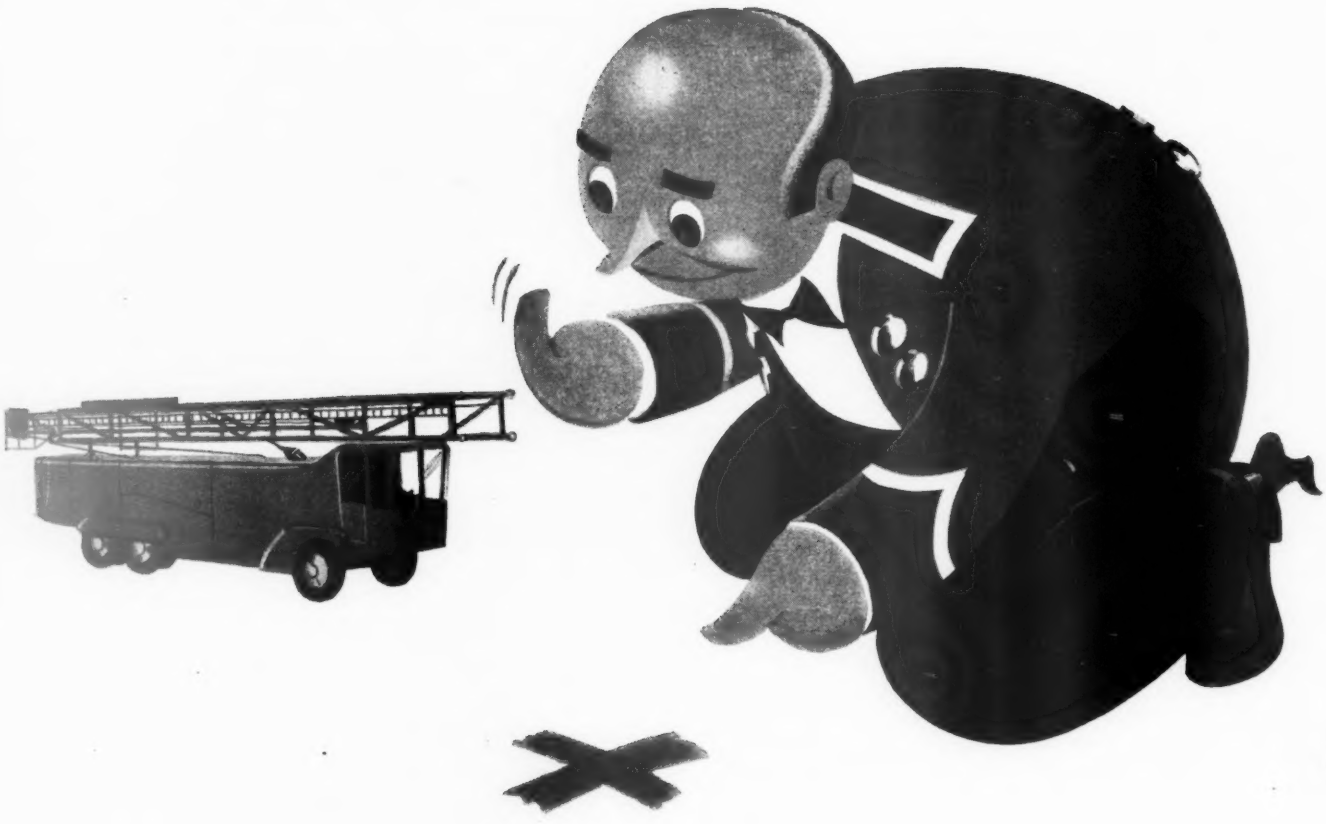
FIG. 2. Fully equipped standard oilfield power unit brake horsepower rpm curve for 4⅝ in. by 6 in. for 605 cu in. gas engine.

Taking into account pumping unit efficiencies that average approximately 80 per cent, a brake horsepower of 17.5 would be required to supply 15 polished rod hp.

The engine size may also be selected from the engine manufacturers' power curves for standard power units and natural gas fuel. The API recommended horsepower curve is 65 per cent of the maximum corrected horsepower curve as shown on Fig. 2. (See API Std. 11-C Internal Combustion Engines and Clutches for Oil Field Services.)

Taken from the article, "Selection of multi-cylinder gas engines," by Fred E. Hummel, Shell Oil Company, Inc., that was published in The Petroleum Engineer, April, 1947, pages 120 to 126, inclusive.

Nose first



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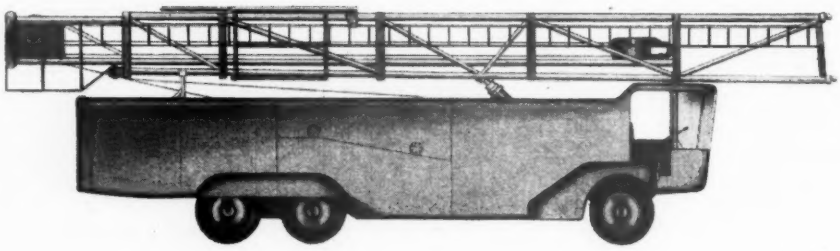

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METHODS OF DETERMINING CONDENSATE CONTENT OF NATURAL GAS

Line samplers A and B, Figs. 12 and 13, were tested at both Katy or Erath over a limited range of conditions while Sampler C, Fig 14*, was tested only at Erath. In general the effect of a line sampler is to permit the use of a short device rather than a pipe section of 60 diameters in length. The line samplers appear to be sensitive to the same variables as straight pipe sampling section and introduce a greater pressure drop. From the tests conducted it appears that any one of these line samplers can be calibrated to give reliable results under specified conditions. The data on each sampler are summarized with the appropriate conclusions.

Line sampler A was used at Erath[8] and at Katy [7b] with the results as given in Table I. Comparison of the last seven lines indicates that the results obtained at Katy with Sampler A in the horizontal position with the tip at the 12-in. position are in agreement with the results obtained at Erath with the Sampler in the vertical position and with similar tip positions of 10⅝ in. and 14 in. The results with the tip at the 6-in position at Katy are also consistent with the results obained a Erath when compared with the data for the 2¾-in tip position. The data of Table I indicate that sampler A may be used in either the vertical or horizontal position with the tips 12 in. downstream from the orifice (plus or minus 1 in.) to give the correct sample within plus or minus 4 per cent on mixtures containing about 1 gal. per M., at a velocity ratio of about 0.7 for flow rates of 8,000,000 cu ft per day if the sampling pressure is 1500 lb per sq in., or for flow rates over 3,000,000 cu ft per day if the pressure is above 2000 lb per sq in. No tests have been made at 1500 lb and flow rates of 3,000,000 cu ft.

Line sampler B was used at Erath[8] and at Katy[7b] but the range of velocity ratios covered at Katy did not exceed 1.0 and the correction factors varied from 0.6 to 0.8 depending upon the liquid content of the sample. The data points from Katy (K) are in good agreement with the results from Erath as shown in Fig. 15*.

The Erath report[8] clearly indicates the sensitivity of this device to tip position. The data shown on Fig 15 were obtained with the tip in the original position and there is no information indicating that the tip position was changed between the tests at Katy and at Erath.

*See sheet 6 P771.2 for Figs. 14 and 15.

NOTE: References are given on sheet 4, P771.2, published in the July, 1947, issue of *The Petroleum Engineer*, page 131.

Taken from the paper, "Sampling two-phase streams from high pressure condensate wells," by Donald L. Katz and George Granger Brown, presented before Natural Gasoline Association of America, Dallas, Texas, April 18, 1946, and published in The Petroleum Engineer, March, 1947, pages 95 to 106, inclusive.

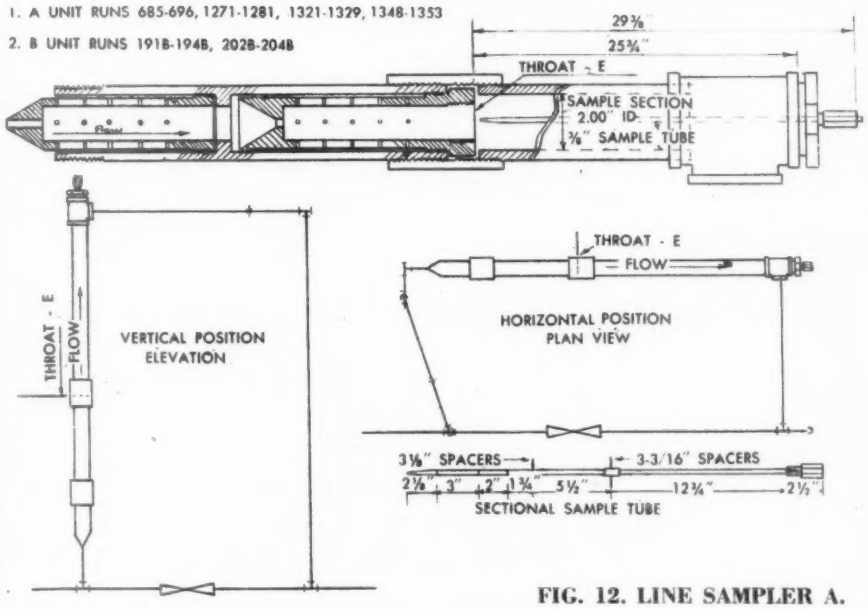


FIG. 12. LINE SAMPLER A.

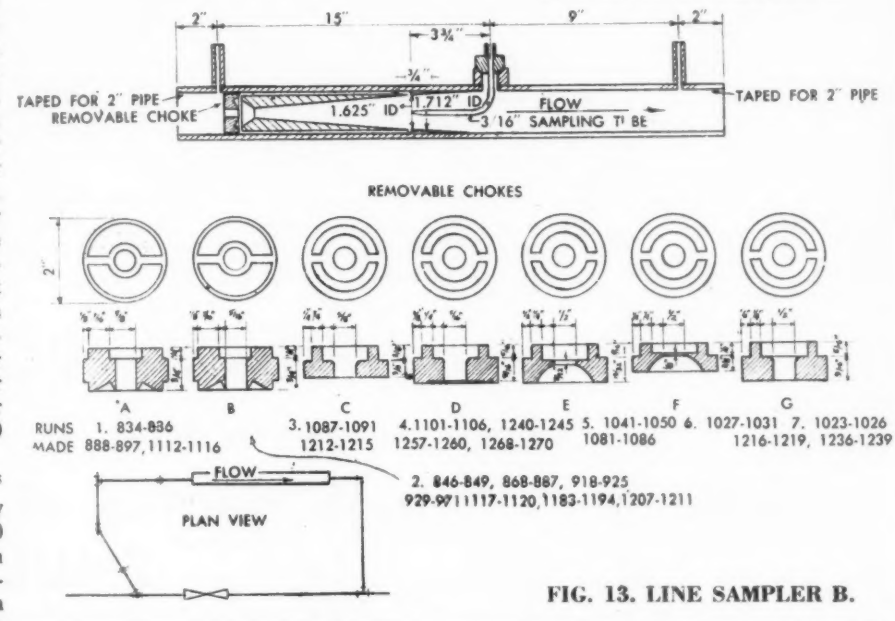
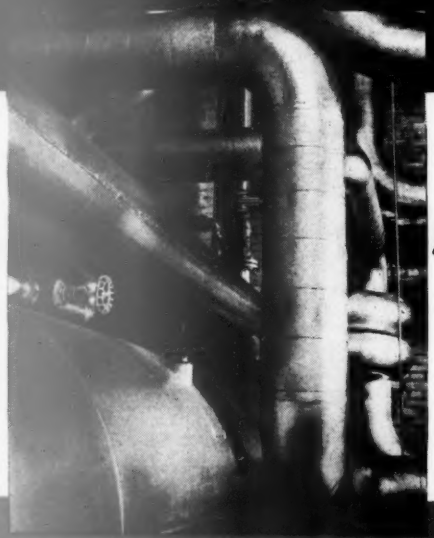


FIG. 13. LINE SAMPLER B.

TABLE I—Summary of all useful data taken with line sampler A at Katy and Erath.

Run no.†	Flow rate, MM. cu ft per day	Pressure	Tip position	Gal per M.	Velocity ratio for correct sample
			Horizontal position		
E191B	4.9	2200	2¾ in.	1	3.27
E202B	8.3	2300	2¾ in.	1	3.27
E685	8.5	1350	2¾ in.	1	2.04*
K79-81	6.3		6 in.	0.4	0.8
K74-78	7.3		6 in.	1	1.5*
K	8.0	2000	12 in.	0.4	0.72
K	8.0	1500	12 in.	0.4	0.63
K_1	8.0	1500	12 in.	1.4	0.72
			Vertical position		
E1271	8.0	2300	14 in.	1.0	0.64
E1276	8.0	2300	10⅝ in.	1.0	0.65
E1348	3.0	2230	10⅝ in.	1.0	0.76
E1351	3.0	2850	10⅝ in.	1.0	0.55*

*Extrapolated. †Prefix E means Erath data; Prefix K means Katy data.



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METHODS OF DETERMINING CONDENSATE CONTENT OF NATURAL GAS

The curves representing the Katy tests indicate that the correction factor at a given velocity ratio becomes smaller by about 0.1 as the liquid content of the stream increases from about 0.4 to 1.8 gal. per M.

With the tip adjusted to a new position about ¾ in. downstream satisfactory results were obtained at Erath at a velocity ratio of 1.22.

Line sampler C was used at Erath and was given a rather thorough test in the vertical position at 0.7 to 1.0 lb per sq in. with the tip 8 in. downstream from the packing retainer plate with results as plotted in Fig. 16. This device is sensitive to tip position. Packed line sampler C in the vertical position with the tip 8 in. downstream from the packing may be expected to give satisfactory results at a velocity ratio of 0.9 at flow rates not less than 7,000,000 cu ft per day at pressures not less than 1500 lb. per sq in., or not less than 5,000,000 cu ft per day at pressures not less than 2300 lb per sq in., or not less than 3,000,000 cu ft per day at pressures of 3000 lb per sq. in. at about 1 gal per M. The correct sample within ±7 per cent may be expected using a velocity ratio of 0.85 for all flow rates from 3,000,000 to 8,000,000 cu ft per day at pressures from 1300 to 3000 lb per sq in. at about 1 gal per M. (Fig 17.)

NOTE: References are given on sheet 4, P-771.2, published in the July, 1947, issue of *The Petroleum Engineer*, page 131.

Taken from the paper, "Sampling Two-Phase Streams From High-Pressure Condensate Wells," by Donald L. Katz and George Granger Brown, presented before Natural Gasoline Association of America, Dallas, Texas, April 18, 1946, and published in The Petroleum Engineer, March, 1947, pages 95 to 106, inclusive.

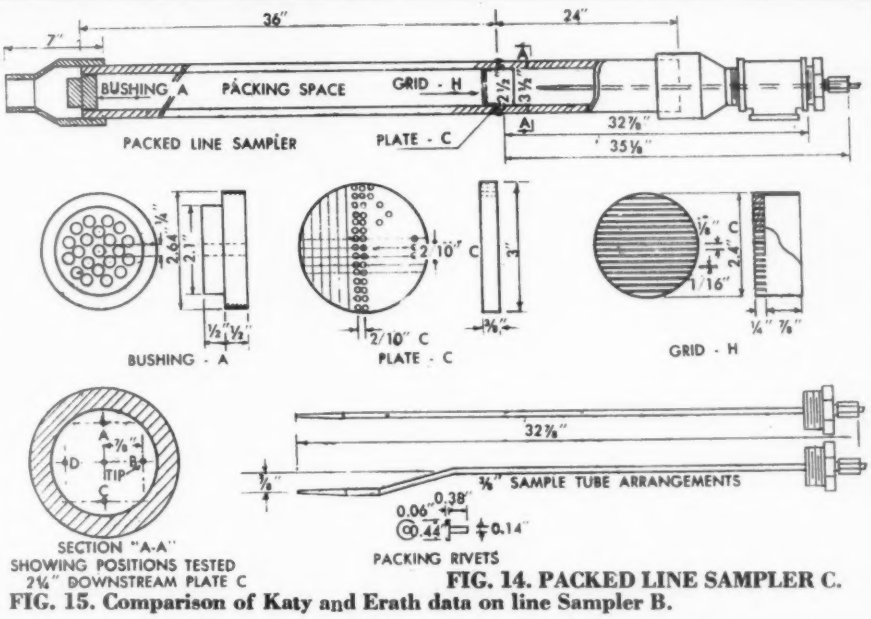


FIG. 14. PACKED LINE SAMPLER C.

FIG. 15. Comparison of Katy and Erath data on line Sampler B.

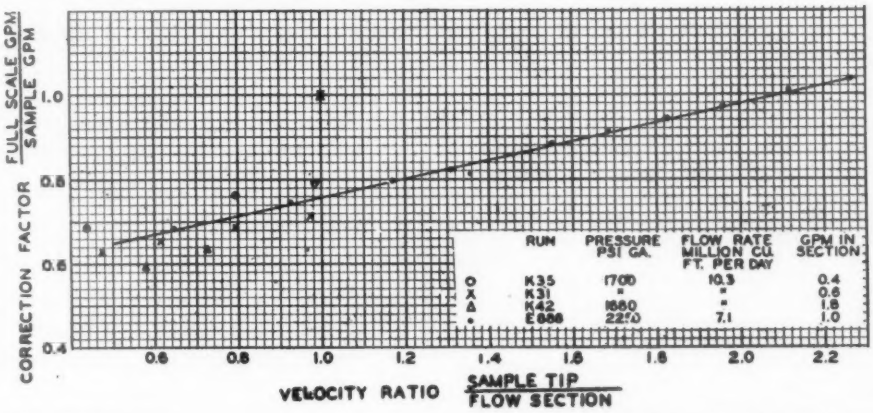

CORRECTION FACTOR FULL SCALE GPM / SAMPLE GPM
VELOCITY RATIO SAMPLE TIP / FLOW SECTION
RUN
PRESSURE PSI GA.
FLOW RATE MILLION CU. FT. PER DAY
GPM IN SECTION
K35 1700 10.3 0.4
K31 " " 0.8
K42 1880 " 1.8
E858 2270 7.1 1.0

FIG. 16. Vertical packer Sampler C, tip 8 in. from plate.

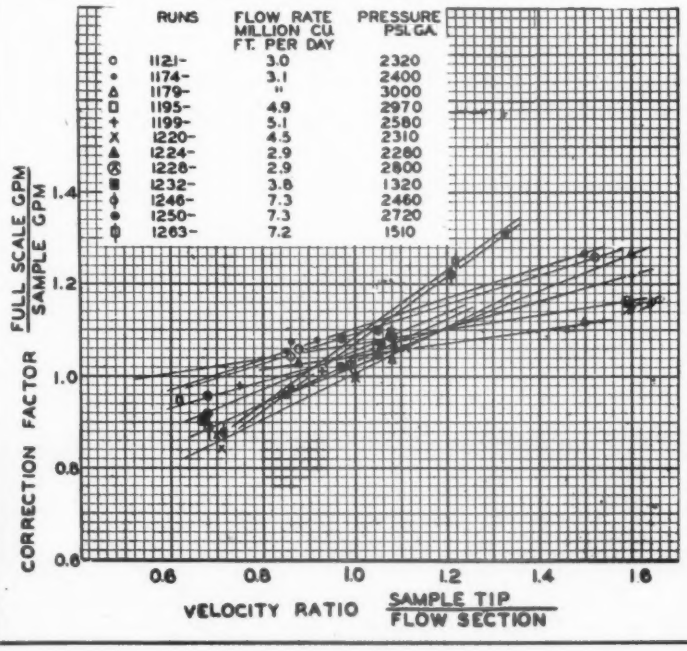
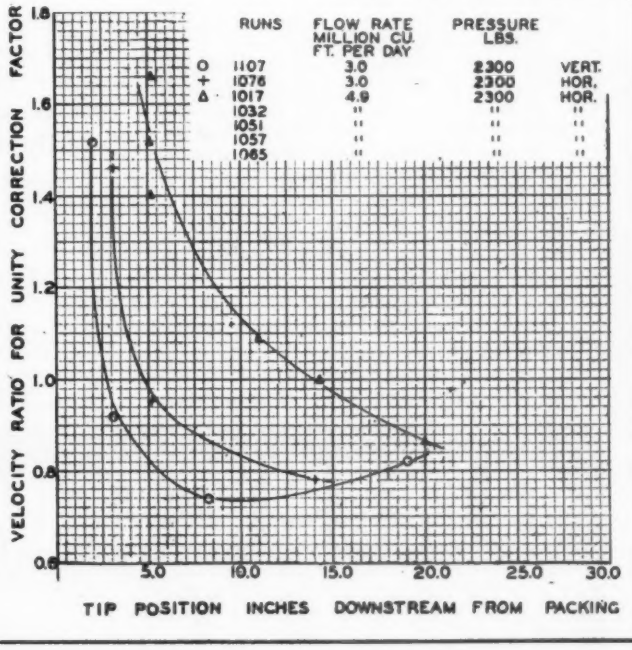


FIG. 17. Packed Sampler C.



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METHODS OF DETERMINING CONDENSATE CONTENT OF NATURAL GAS

In order to compare the results at Katy and Erath on vertical and horizontal pipe sampling sections it is necessary to express the flow rates and tip positions as a function of the diameter of the sampling section, since four sizes of pipe (0.599, 1.689, 1.735, and 3.438 in. diam.) were used in the Katy tests and only one size (2.0 in. diam.) was used in the Erath tests. The tip position is expressed in terms of the number of pipe diameters equal to the distance the tip is downstream from the nearest disturbance, and the flow rate is expressed in terms of millions of standard cubic feet of gas per day per inch of internal diameter of pipe.

The Reynolds number for a fluid flowing through a pipe is the best criterion for expressing the turbulence of a fluid stream. The Reynolds number varies directly as the diameter of the pipe and as the mass flow velocity. For this reason the total flow rate through the sampling section is divided by the diameter of the pipe to express quotient which would be proportional to the Reynolds number. Therefore, flow rate in millions of cubic feet per day per inch of pipe diameter appears to be a sound basis of comparison for the velocities which would present similar sampling conditions. Comparison of the results on the sampling sections of different diameters also confirmed this theoretical conclusion.

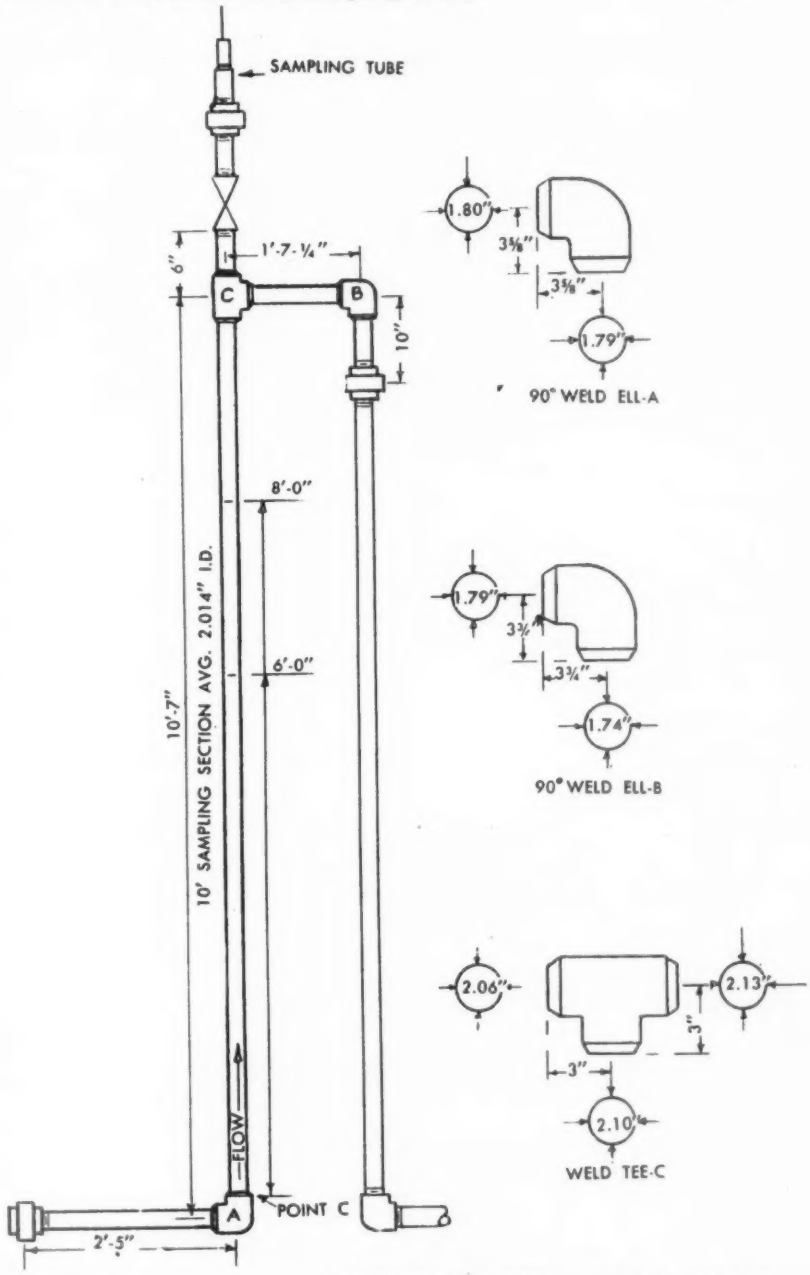
All of the five conclusions based on the Katy tests (page 52, reference 5) have been confirmed by the results obtained at Erath except number 2, which is repeated here because of its importance.

"II. It appears that thin walled sharp tips may give a representative sample if used at a constant velocity ratio of about 0.94 at liquid content from 0 to well in excess of 10 per cent by volume (6.62 gal. per M. (GPM) at 1500 lb per sq in.) in either horizontal or vertical sample lines provided there is a minimum straight section of about 40 diameters in length upstream of the tip and about 15 diameters downstream, and the velocity in the sampling section is sufficient to develop the required degree of turbulence."

Several vertical sections varying from 1.5 to 3.5 in. I.D. were tested. Fig. 18 shows one of the 2-in. I. D. vertical sections tested at Erath. Fig. 19 (sheet 8) gives velocity ratio-correction factor curves obtained using straight taper tips in this section.

Although no data for different liquid contents were obtainable at Erath, the data taken at Erath at about 1 gal. per M. liquid content are in excellent agreement with the data taken at Katy under corresponding conditions. This comparison can be made best by a plot of the Katy and Erath data showing the velocity ratio for the correct sample as a function of liquid content expressed as gal. per M. in the flowing stream. This has been done in Fig. 20, which includes all the data on sampling in a vertical section with a blunt tip. All of these data were obtained at a tip position of 42 pipe diameters and at a sufficiently high flow rate so that flow rate is not a variable affecting the velocity ratio of the correct sample. The data on the blunt tip obtained at Katy are in excellent agreement with the single test series made at Erath with a blunt tip. The lower curve in Fig. 20 representing the data obtained with a blunt tip indicates the sensitivity of blunt tips to the liquid content in the sampling section.

FIG. 18. Welded 10-ft vertical sampling section.



1. B UNIT RUNS 205B-242-B, 254B-267B, 290B-308B
2. A UNIT RUNS 1282-1320, 1330-1347, 1354-1365

Although the effect of liquid content was not studied independently at Erath the agreement between the Katy and Erath data confirms the accuracy of the limited data obtained at Katy and strengthens the conclusions derived therefrom that the sharp tips give results that are independent of liquid content.

NOTE: References are given on sheet 4, P-771.2, published in the July, 1947, issue of *The Petroleum Engineer*, page 131.

Taken from the paper, "Sampling two-phase streams from high pressure condensate wells," by Donald L. Katz and George Granger Brown, presented before Natural Gasoline Association of America, Dallas, Texas, April 18, 1946, and published in The Petroleum Engineer, April, 1947, pages 78 to 86, inclusive.

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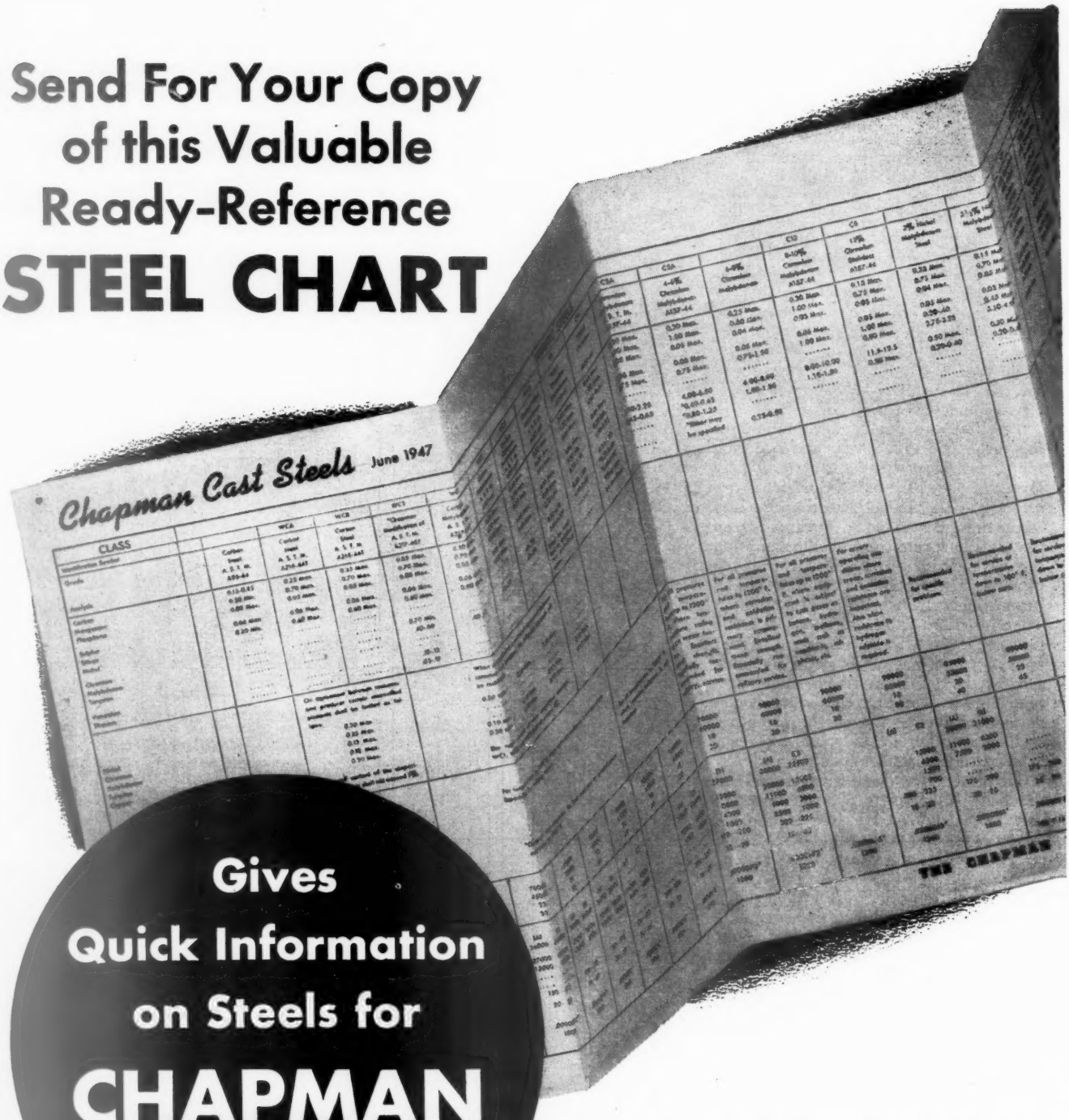

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METHODS OF DETERMINING CONDENSATE CONTENT OF NATURAL GAS

FIG. 19. Welded vertical section tip 8 ft from ell.

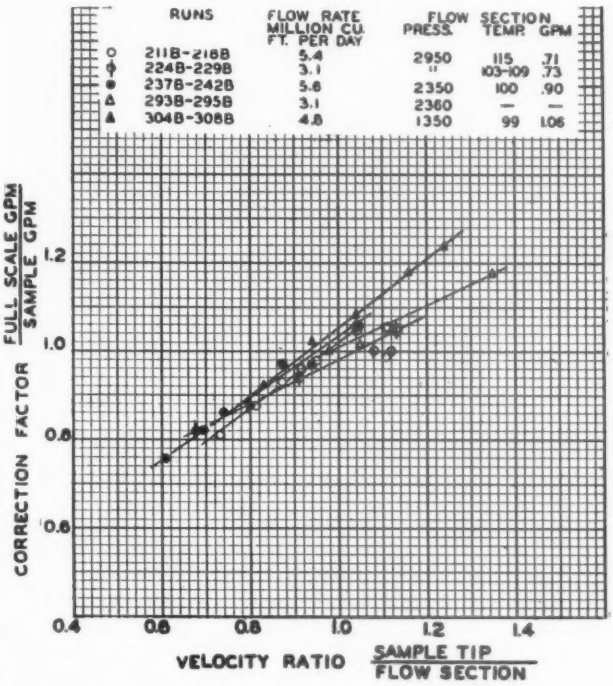
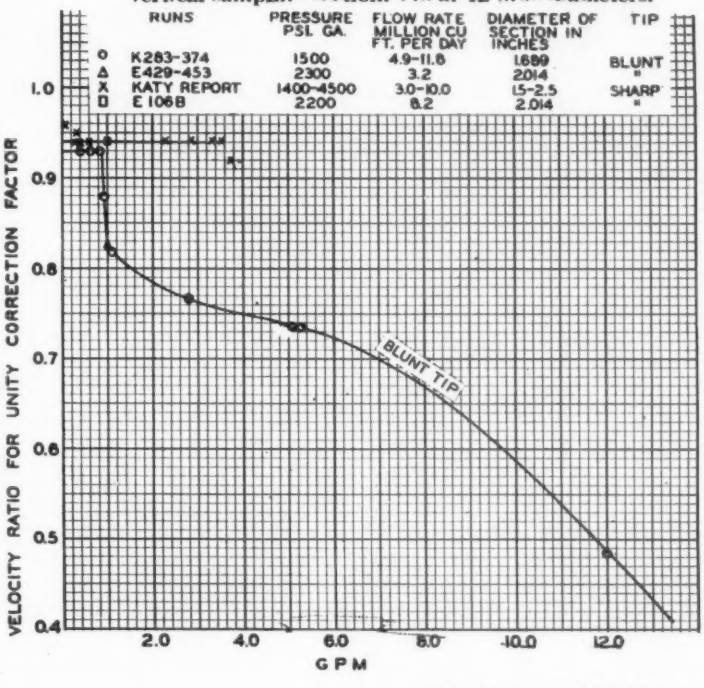

RUNS
FLOW RATE MILLION CU FT. PER DAY
FLOW PRESS.
SECTION TEMP.
GPM
○ 211B-218B 5.4 2950 115 .71
ϕ 224B-229B 3.1 " 103-109 .73
● 237B-242B 5.8 2350 100 .90
△ 293B-295B 3.1 2360 — —
▲ 304B-308B 4.8 1350 99 1.06
CORRECTION FACTOR FULL SCALE GPM / SAMPLE GPM
VELOCITY RATIO SAMPLE TIP / FLOW SECTION

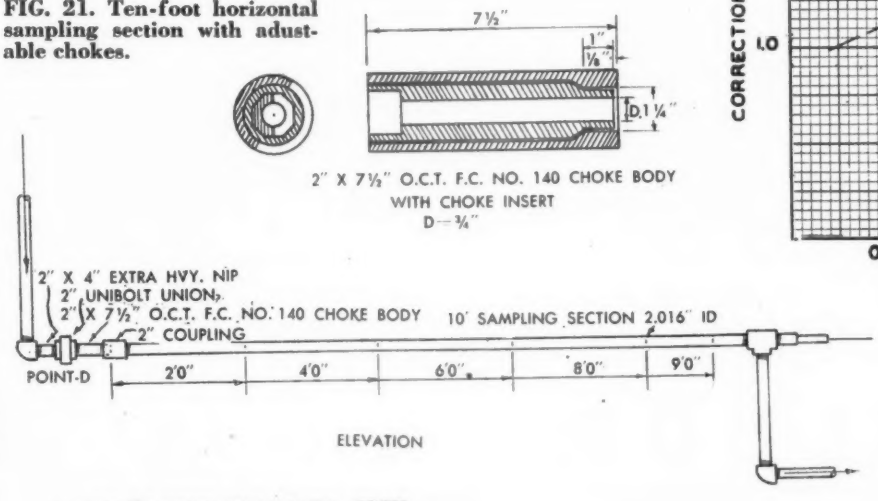
FIG. 20. Comparison of Katy and Erath data on vertical sampling section. Tip at 42 pipe diameters.


RUNS
PRESSURE PSI GA.
FLOW RATE MILLION CU FT. PER DAY
DIAMETER OF SECTION IN INCHES
TIP
○ K283-374 1500 4.9-11.8 1.689 BLUNT
△ E429-453 2300 3.2 2.014 "
X KATY REPORT 1400-4500 3.0-10.0 1.5-2.5 SHARP
□ E 1068 2200 8.2 2.014 "
VELOCITY RATIO FOR UNITY CORRECTION FACTOR
BLUNT TIP
GPM

Data in the Katy report[7a,9] taken with sharp tips inserted and centered in the well tubing are also plotted on Fig. 20 as X's and indicate that the liquid content at least up to 3.5 gal. per M. had no effect upon the velocity ratio for the correct sample when sharp tips were used. Fig. 21 is one of the horizontal sections tested at Erath. In the horizontal position the effect of gravity is to tend to cause the liquid to flow along the bottom of the pipe. At low velocities where turbulence is not sufficient to overcome the effect of gravity the liquid content at the center of the pipe decreases at increasing distances down stream from the last disturbance. Accordingly the velocity ratio for the correct sample will steadily decrease as the tip is moved farther downstream from the last disturbanee under low flow velocities.

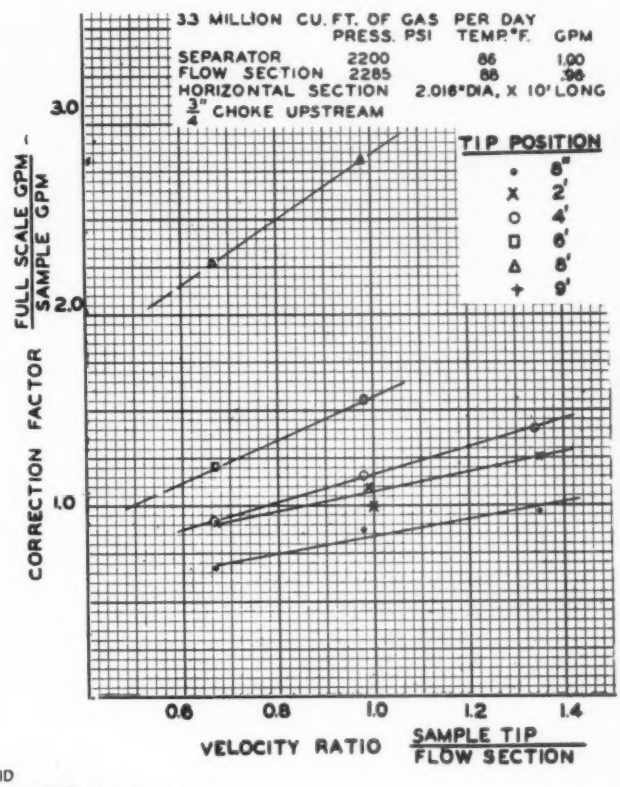
This observation is borne out by the data plotted in Fig. 22. These data were obtained in the horizontal sampling section shown in Fig. 21 which includes a ¾-in. choke at the upstream end of the horizontal section.

FIG. 21. Ten-foot horizontal sampling section with adustable chokes.



1. WITH ¾" CHOKE RUNS 585-596, 697-728
2. WITH CHOKE ONLY (1¼") RUNS 597-684, 786-807

FIG. 22. Runs 41B-54B.


33 MILLION CU. FT. OF GAS PER DAY
PRESS. PSI TEMP. °F. GPM
SEPARATOR 2200 86 1.00
FLOW SECTION 2285 88 .98
HORIZONTAL SECTION 2.016" DIA. X 10' LONG
¾" CHOKE UPSTREAM
TIP POSITION
• 8"
X 2'
○ 4'
□ 6'
△ 8'
+ 9'
CORRECTION FACTOR FULL SCALE GPM / SAMPLE GPM
VELOCITY RATIO SAMPLE TIP / FLOW SECTION

NOTE: References are given on sheet 4, P-771.2, published in the July, 1947, issue of *The Petroleum Engineer*, page 131.

Taken from the paper, "Sampling two-phase streams from high pressure condensate wells," by Donald L. Katz and George Granger Brown, presented before Natural Gasoline Association of America, Dallas, Texas, April 18, 1946, and published in The Petroleum Engineer, April, 1947, pages 78 to 86, inclusive.

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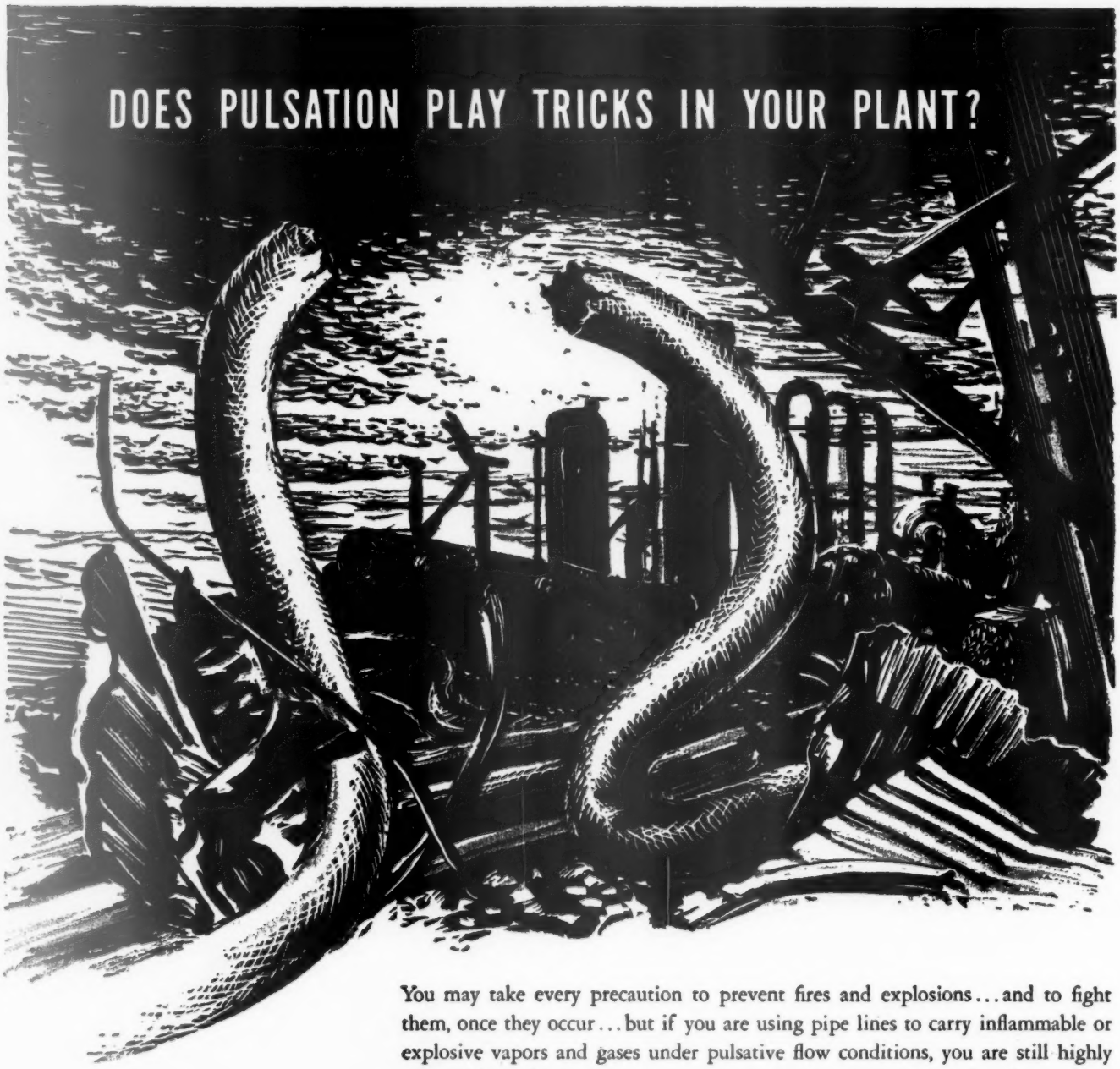

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METHODS OF DETERMINING CONDENSATE CONTENT OF NATURAL GAS

FIG. 23. Runs 633-654.

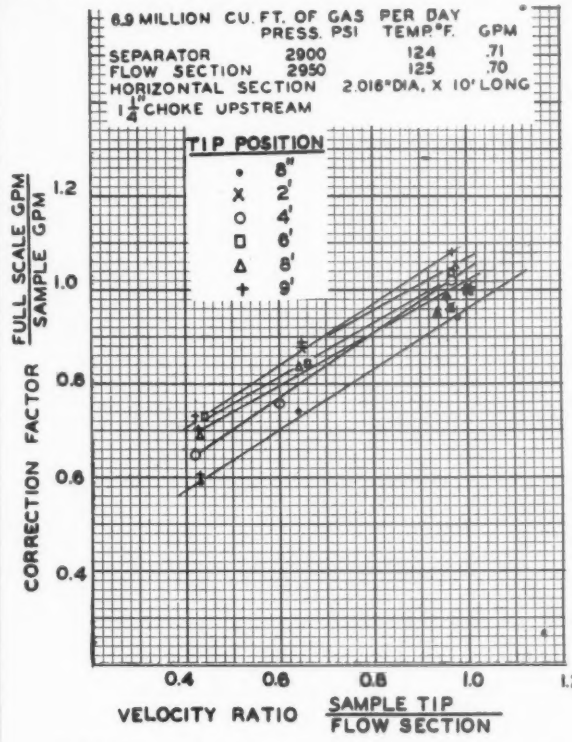
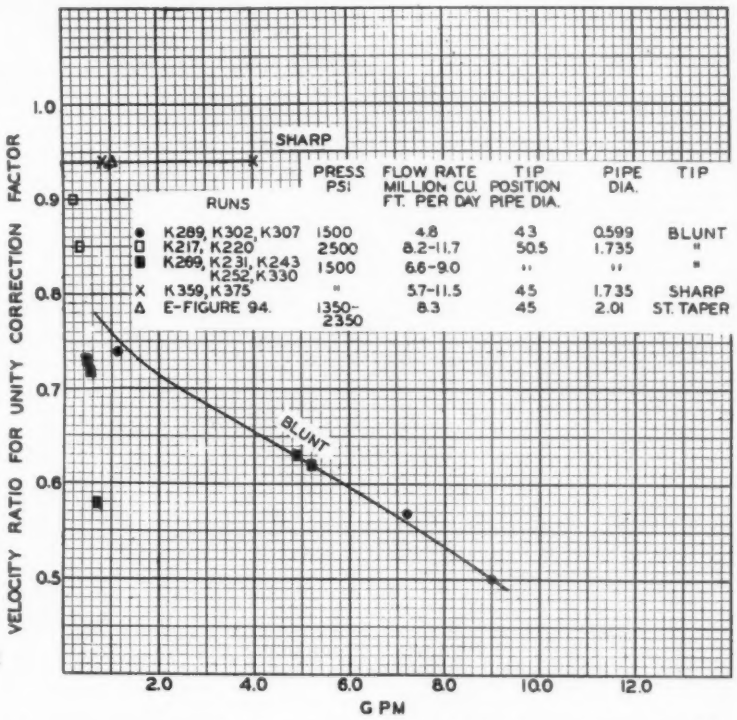


FIG. 24. Effect of GPM on velocity ratio for unity correction factor in horizontal sampling sections with sharp tips and blunt tips.


VELOCITY RATIO FOR UNITY CORRECTION FACTOR
1.0
0.9
0.8
0.7
0.6
0.5
SHARP
BLUNT
RUNS | PRESS PSI | FLOW RATE MILLION CU. FT. PER DAY | TIP POSITION PIPE DIA. | PIPE DIA. | TIP
● K289, K302, K307 | 1500 | 4.8 | 43 | 0.599 | BLUNT
□ K217, K220 | 2500 | 8.2-11.7 | 50.5 | 1.735 | "
■ K269, K231, K243, K252, K330 | 1500 | 6.6-9.0 | " | " | "
X K359, K375 | " | 5.7-11.5 | 45 | 1.735 | SHARP
△ E-FIGURE 94. | 1350-2350 | 8.3 | 45 | 2.01 | ST. TAPER
2.0 4.0 6.0 8.0 10.0 12.0
G PM

At high flow rates the effect of turbulence tends to overcome the effect of gravity and the variation in liquid distribution with distance downstream from the disturbance becomes of much less significance and it is possible to obtain a correct sample at a reasonably high velocity ratio over a relatively long distance of the sampling section. This condition is indicated by the data plotted in Fig. 23.

The results with the blunt tip in a horizontal sampling section of 0.599 in. in. I.D. are plotted in Fig. 24 as △ indiposition of 43 pipe diameters. These data were taken at flow rates of about 4.8 million cu. ft. per day corresponding to about 8,000,000 cu. ft. per inch of pipe diameter. At these high flow rates through small fittings and small sampling sections, the total pressure drop amounted to about 120 lb per sq in. This flow rate is at the same velocity as would result from flowing about 53,000,000 cu. ft. through a sampling section of 2 in. I.D., and indicates that a 2-in. I.D. sampling section may be used at flow rates up to at least 50 million cu. ft. per day if a pressure drop of about 120 lb. per sq. in. can be tolerated.

Additional results with a blunt tip at 50.5 pipe diameters in a horizontal section of 1.735 in. I.D. are also plotted in Fig. 24, representing all the data reported as reliable[7a]. These data were taken with flow rates of not less than 4,000,000 cu. ft. per day, corresponding to 2.3 million cu. ft. per inch of pipe diameter, and are consistent with the data taken on the smaller pipe.

The tests at Erath using straight tapered tips in a horizontal section of 2 in I.D. are plotted in Fig. 24 as △ indicate that with the tip at the 7.5 ft. position (45 pipe diameters) a satisfactory sample would be obtained whenever the flow rate was not less than about 6,000,000 cu. ft. per day (3,000,000 cu. ft. per in. of pipe diameter) at about 2000 lb. per sq. in.

● **Discussion.** In all of the data reported from the tests at Katy and Erath the values for gal. per M. represent the actual liquid phase present in gallons per thousand standard cubic feet of gas. These values of gal. per M. are not the total recoverable liquid hydrocarbons present but simply the actual liquid present under the conditions indicated. The total recoverable liquid hydrocarbons will in all cases be greater than the reported gal. per M. in these tests. For example the total recoverable butane plus from the gas used at Erath amounts to 1.8 gal. per M. while the actual content under sampling conditions varied from about 0.7 to 1.0 gal. per M. Accordingly an error of 4 per cent in sampling when the sample separator is operating at about the same pressure as that of the sampling section, means an error of 4 per cent on 0.7 gal. per M. or 0.028 gal. per M. Figured on the total liquid recoverable at 1.8 gal. per M. this means an error of 0.028 divided by 1.8 or 1.5 per cent. This represents the accuracy with which the total recoverable liquid would be determined although the accuracy of the sampling of the two phase stream is ± 4 per cent for the conditions indicated.

In the Katy tests the separators were operated at about 830 lb. per sq. in. and 100° F. These conditions correspond to about twice the actual liquid in the separator as that which was present in the sampling section. This increase in liquid in the sample as its pressure is reduced from that in the sampling section to the 830 lb. per sq. in. in the separator comes entirely from the gas phase. Since the gas phase is sampled without error regardless of the velocity ratio, approximately half of the liquid in the separator is free from all error. The error based on the liquid in the separator at Katy for the well stream is therefore one-half the error in sampling the two phase stream in the sampling section. Therefore the criterion for satisfactory sampling at Katy (± 2 per cent of the separator gal. per M.) is equivalent to an error of about ± 4 per cent in sampling the liquid in the two phase stream in the sampling section.

The comments and conclusions do not necessarily apply to stream containing substantial quantities of water.

NOTE: References are given on sheet 4, P-771.2, published in the July, 1947, issue of *The Petroleum Engineer*, page 131.

Taken from the paper, "Sampling two-phase streams from high pressure condensate wells," by Donald L. Katz and George Granger Brown, presented before Natural Gasoline Association of America, Dallas, Texas, April 18, 1946, and published in The Petroleum Engineer, April, 1947, pages 78 to 86, inclusive.

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METHODS OF DETERMINING CONDENSATE CONTENT OF NATURAL GAS

● **Suggested procedure for sampling in straight pipe.** The agreement among all of the tests run either in well tubings, or at Katy, or at Erath indicate that the methods used will give identical results in different equipment of different sizes provided the following procedure is used.

1. Straight pipe sampling section.
   (a) Length 60 diameters or more
   (b) Inside diameter must be known and the tubing should be clean, smooth and straight.
   (c) The recommended minimum flow rate per inch of pipe diameter, and the corresponding maximum pipe diameter per million cubic feet of flow rate are given in Table 2.
   (d) In vertical sampling sections the tip position should be not less than 45 pipe diameters downstream from the last disturbance with 15 diameters of the straight section continued downstream from the tip. The flow rate should be not less than that indicated in Table 2 for a velocity ratio of 0.94.
   (e) In horizontal straight tube sampling section, the tip should be placed at approximately 45 diameters downstream from the last disturbance in a straight sampling section of at least 60 pipe diameters in length, and flow rate should be not less than that indicated in Table 2 for a velocity ratio of 0.94.
2. Tips
   (a) Sharp edge tips of the type shown in Fig. 10 (of the proceedings of the Annual Meeting NGAA, page 51, 1944,) or the equivalent.
   (b) The sample tube supporting the tip and connecting the sample to the sample separator should be of the minimum consistent diameter.
   (c) The tips should be well centered by a sturdy centering device or spider downstream from the tip.
   (d) Tips can be permanently fixed in sample sections or inserted by any suitable means provided its position is known and controlled.
   (e) Size of the tip should be, preferably, not less than ⅛ in. I.D. and generally as large as is practical and still bracket the velocity ratio of 0.94 without exceeding the capacity of the small scale separator.
3. Sample separator.
   (a) Must be so designed as to give complete separation of gas from the liquid under the conditions of use.
   (b) The gas handling capacity must be at least adequate to handle the maximum flow rates with a tip not less than ⅛ in. I.D. The gas sampling rates given in Table 3 are required for a velocity ratio of 0.94.
   (c) Must have liquid capacity sufficient to handle the liquid accompanying the maximum flow rate on the richest stream, and give an accumulation time of at least five minutes. It should also be designed to permit accurate readings to be taken at intervals of not less than 15 minutes on the leanest sample to be taken with a gas sample rate well below the maximum capacity of the separator.
   (d) Separator must be equipped with means for controlling its temperature and pressure under flow conditions and suitable and reliable means for measuring the gas flow. The combination of an integrating flow meter to give the total gas flow with an orifice to indicate the instantaneous flow rate, or an orifice gas meter alone is satisfactory.
   (e) The sample should be brought to the temperature and pressure of the separator before it is introduced into the separator so that it enters the separator at the same conditions that are maintained therein.

Sample gas rate, cu. ft. per hr.	500	1000	5000
Gal. per M. in separator	cc. liquid in 5 min.	cc. liquid in 5 min.	cc. liquid in 5 min.
0.2	31	63	315
0.4	63	126	630
0.6	94	189	945
0.8	126	252	1260
1.0	157	315	1575
1.5	236	472	2360
2.0	315	630	3150
3.0	472	945	4725
4.0	630	1260	6300

● **Conclusions.** Suitable conditions for sampling a mixed stream have been determined and stated for straight pipe sampling sections in either the vertical or horizontal position. The minimum flow rate or maximum pipe diameters required to give satisfactory results have been indicated as a function of flow rate and flow pressures.

All the available data indicate that the specified sampling conditions will give reliable results for liquid contents up to 12 gal. per M. However, these conclusions for gal. per M. above 1.1 are based on a very few tests which should be made to remove any doubt concerning this point.

Tests so far conducted indicate that various line samplers can be calibrated to give results comparable to a properly calibrated straight pipe sampling section. Provided such line samplers are properly calibrated it appears that it is mainly a matter of personal preference whether a straight pipe sampling section or a line sampler be used.

TABLE 2. Minimum flow rates and maximum pipe diameters for plain tube sampling with a velocity ratio of 0.94.

Pressure not less than (lb. per sq. in.)	Minimum flow rate, MM. cu. ft. per in. pipe diameter		Maximum pipe diameter in inches per MM. cu. ft. of flow rate	
	Vertical	Horizontal	Vertical	Horizontal
1200	2.5	4.3	0.4	0.23
1800	1.7		0.6	
2200	1.5	3.0	0.66	0.33

TABLE 3. Sample gas capacity, cu ft per hr.

Tip size, in.		0.125 (8/64)	0.157 (10/64)	0.189 (12/64)
Well flow rate				
MM. cu. ft. per day	M. cu. ft. per hr.			
		1.00 in. I. D.	Sample section	
2.0	83	1222	1930	
5.0	208	3045	4820	
10.0	416	6110	10260	
		2.00 in. I. D.	Sample section	
3.0	125	459	724	1050
5.0	208	764	1200	1750
10.0	416	1528	2400	3500
20.0	832	3056	4800	7000

NOTE: References are given on sheet 4, P-771.2, published in the July, 1947, issue of *The Petroleum Engineer*, page 131.

Taken from the paper, "Sampling two-phase streams from high pressure condensate wells," by Donald L. Katz and George Granger Brown, presented before Natural Gasoline Association of America, Dallas, Texas, April 18, 1946, and published in The Petroleum Engineer, April, 1947, pages 78 to 86, inclusive.

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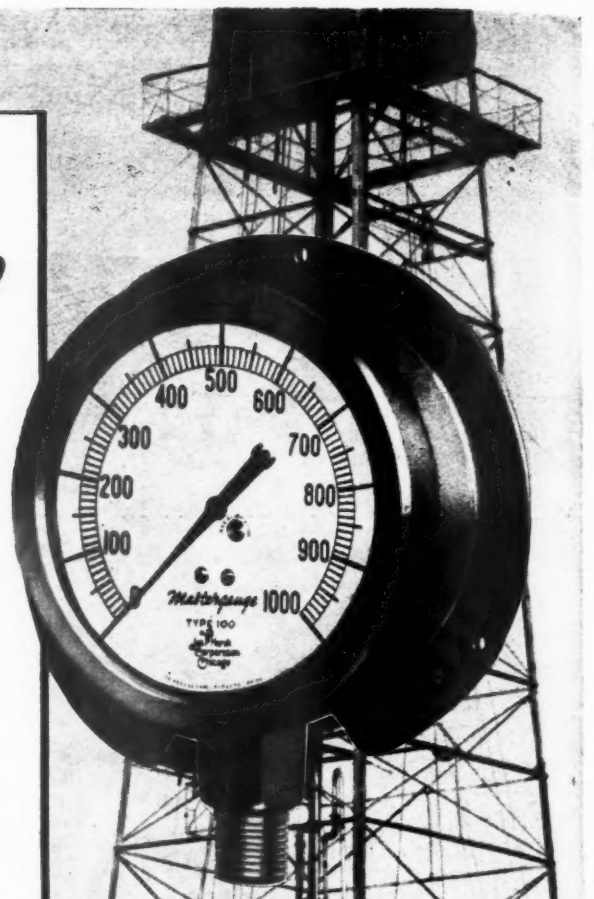

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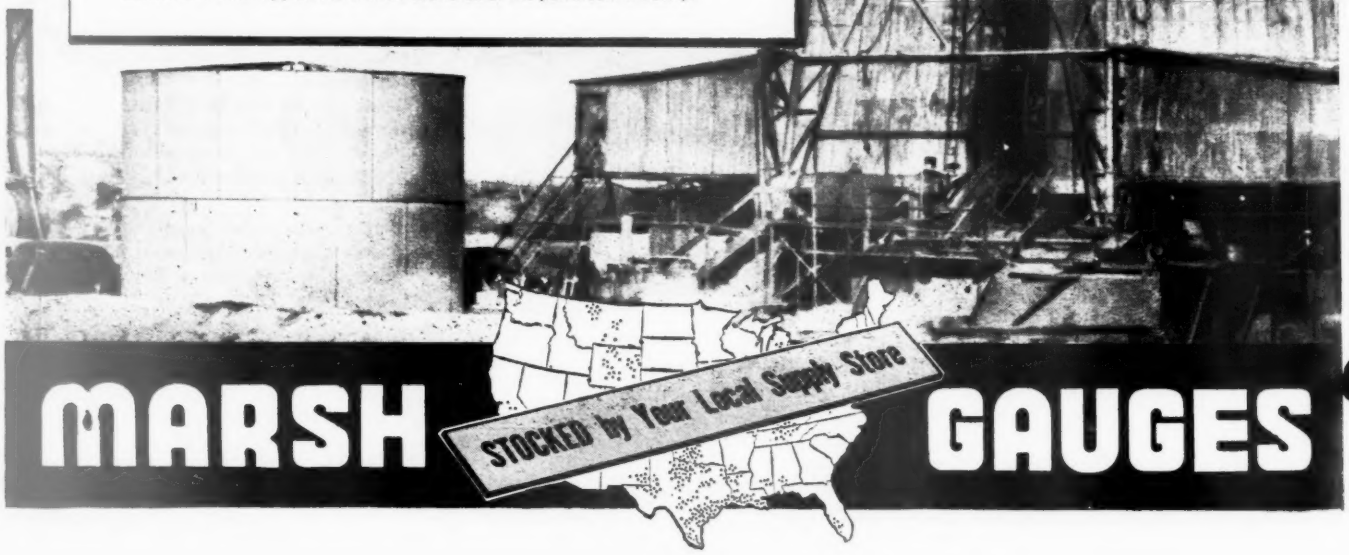

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● **Dr. Louis Schmerling** of the Universal Oil Products Company, Chicago, has been awarded the first Ipatieff Prize in chemistry, it is announced by the American Chemical Society, which administers the award. The $3000 prize, honoring achievements in the study of catalysis or high pressure, was established by Dr. Vladimir N. Ipatieff, director of the Ipatieff High Pressure and Catalytic Laboratory at Northwestern University, and Mrs. Ipatieff. The award will be given every three years to a chemist under 40 years of age.

Dr. Ipatieff will present the first award, with a commemorative certificate, to Dr. Schmerling on September 15 at a general assembly of the American Chemical Society in Manhattan Center, New York, in connection with the Society's 112th national meeting.

Dr. Schmerling, who is 35, was cited for his contribution to the knowledge of catalytic reactions of hydrocarbons.

● **Henry N. Greis,** 67, died July 16 in Tulsa, Oklahoma. A pioneer Tulsan, he was president of the Deep Rock Oil Corporation and the Burke-Greis Corporation. When Deep Rock went into receivership, Greis was appointed sole trustee of the corporation for all properties throughout its operating area. A native of Buffalo, New York, he was a graduate of the U. S. Military Academy at West Point.

Henry N. Greis

● **Thomas Patrick Simpson,** for many years a chemical engineer with the General Petroleum Corporation in Los Angeles, has been named director of the Socony-Vacuum Oil Company's research and development laboratories at Paulsboro, New Jersey. Simpson was one of the principal figures in the development of the thermofor catalytic cracking process, which played a vital part in the manufacture of high octane gasoline for the armed services during the war. He joined General Petroleum as a chemical engineer in 1923 and was a graduate of the California Institute of Technology, with a bachelor of science degree. In 1933 he was named supervisor of process laboratories and, two years later, was transferred to Socony-Vacuum as chief development engineer. In 1944 he was appointed assistant director of research.

T. P. Simpson

● **"Jack" Clemens,** who recently returned to the States from a six and one-half month's South American trip covering Trinidad, Colombia, Ecuador, Peru, Chile, Argentina, Brazil, Mexico, Venezuela, and Bolivia, and **"Mutt" Donovan,** Martin-Decker factory engineer, who has been stationed in Texas and Louisiana, have just completed an intensive study of product development at

"Jack" Clemens

"Mutt" Donovan

the Martin-Decker plant in Long Beach California. "Jack" Clemens is now stationed at Houston, Texas, where he will assist Gulf Coast customers in the use of Martin-Decker products. "Mutt" Donovan is now servicing the Mid-Continent from headquarters in Oklahoma City.

● **James R. Weaver,** works manager of the East Springfield Works, Westinghouse Electric Corporation, has been appointed a director of the Wico Electric Company, West Springfield, Massachusetts.

● **Dr. Harold Jeskey,** associate professor of organic chemistry at Southern Methodist University, has been elected chairman of the Dallas-Fort Worth Section of the American Chemical Society. He succeeds **Maurice O. Barr** of the Eagle-Picher Sales Company.

Other new officers of the section are: H. T. Brown of the Texas Research Foundation, chairman-elect; T. S. McDonald of the Proctor and Gamble Company, secretary, and Madison Marshall of Texas State College for Women, treasurer.

● **Jack S. Smith,** manager of operations and sales for International Cementers, Inc., returned recently from a two months' trip to Europe. He contacted personnel of oil companies in England, Holland, France, Denmark, and Egypt. He suggests, for the benefit of interested vacationists contemplating a trip to the continent, that they "see America first!"

● **Robert D. Fagan** has been appointed sales representative for International Cementers, Inc., in the Long Beach district to replace **M. W. "Monk" Cook,** who has resigned to do selling work in the Near East. Fagan was with Pacific Cementing from 1937 until it was made International Cementers in 1940, as cementer district manager and special representative for the company.

● **D. D. Utterback,** Houston Oil Company of Texas, New Orleans, Louisiana, recently was elected president of the New Orleans Geological Society. Utterback received his Ph.D. degree in geology from the University of Illinois in 1936. He was geologist for The Texas Company from 1936 through 1946, but was on military leave of absence from July, 1942, through May, 1946. At the time of his discharge from military service he held the rank of major. At the present time he is district geologist for his company in the south Louisiana district.

D. D. Utterback

● **Ira A. Brinkerhoff** has been placed in charge of the new Houston, Texas, office of Cummins, Berger and Pishny, engineers and geologists. Announcement also is made that **V. Robert Kerr** is now in charge of seismic interpretation in the company's Fort Worth office.

Brinkerhoff, for the last five years, was chief geologist for the Texas Producing Company, and prior to that was with Stanolind Oil and Gas Company. He is a graduate of the University of Nebraska.

Kerr is a graduate of the University of Colorado and spent 12 years with Cities Service. Prior to joining Cummins, Berger and Pishny last December, he was with Sidney Shaffer in Houston.

● **R. E. Whitten,** familiar figure in the supply business in the Texas Panhandle for many years, has been promoted from manager of the Bovaird supply store at Borger, Texas, to district manager, according to announcement made by D. M. Bradley, vice president of the Bovaird Supply Company. Whitten has been with the Bovaird organization since 1935, and has been associated with the supply end of the oil industry for a quarter-century. Whitten succeeds Dan C. Kennedy who died recently.

R. E. Whitten

● **Dr. J. T. Rettaliata,** director of the department of mechanical engineering of the Illinois Institute of Technology and engineering consultant for the Allis-Chalmers Manufacturing Company, will address the American Institute of Electrical Engineers in Mexico City on August 28 on the subject of "Gas Turbines and Jet Propulsion." This will be one of the first presentations to a foreign audience of progress in gas turbine development by a U. S. manufacturer.

● **Paul Cavins**, general manager of the Cavins Company, is recuperating in Seaside Memorial Hospital, Long Beach, California, after an operation. He is to be discharged shortly and after a convalescent period will be back doing business at the same old stand.

● **L. W. Elliott**, president of Standard-Vacuum Oil Company, has been promoted to brigadier general in the Officers Reserve Corps. Elliott, a staff officer with General MacArthur in the last war, and eight other colonels had been recommended for the promotion by President Truman. The nine men are the first reserve officers who did not serve as general officers during the war to attain this rank in the ORC, according to the War Department.

L. W. Elliott

A veteran of both world wars, Elliott was a private in 1917-18 and served 16 months in France. At the time of Pearl Harbor, he was in the Netherlands East Indies as general manager of Standard-Vacuum Petroleum Maatschappij, then known as NKPM, producing and refining affiliate of Standard-Vacuum.

● **R. N. Giles**, superintendent of technical service in the Whiting, Indiana, laboratories of Standard Oil Company (Indiana), has been promoted to director of technical service with headquarters in the research department at the general office in Chicago. He will be responsible for direction of technical service activities at all the Standard of Indiana refineries. Dr. Giles joined Standard Oil in 1930 after graduate work at Ohio State University. **C. R. Harte**, assistant superintendent of technical service at Whiting, succeeds Dr. Giles. Dr. Harte joined the company in 1936, after graduate work at the University of Michigan and several years of subsequent experience in industry.

W. F. Meehan, a group leader, was advanced to fill the post vacated by Dr. Harte. Meehan became associated with Standard in 1942 after graduation from the University of Detroit. **R. S. McDaniel** succeeds Meehan. **E. B. Tucker** has been appointed section leader in charge of a newly organized research analytical section of the Whiting laboratories. **H. M. Grubb** and **W. L. Rittschof** have been made group leaders in this section. **F. W. Porsche** has been made foreman of the gas analysis laboratories, succeeding Rittschof. **G. W. Flint** has been advanced to section leader in charge of work on specialties. **C. E. Adams** has been appointed section leader in charge of exploratory research on chemical products. **E. J. Campau, A. W. Lindert, D. E. Burney, Philip Hill, W. R. Hertwig,** and **Moses Gordon** have been made group leaders. **Michael Dufinecz** is appointed patent advisor assisting **J. C. Stauffer.**

● **A. D. Fuller**, sales manager, of Waldrip Engineering Company, Hollydale, California, spent most of the month of July visiting the Mid-Continent and Rocky Mountain Fields.

● **M. W. "Monk" Cook** has been appointed Near East sales and service representative for Security Engineering Company, Inc., International Derrick and Equipment Company, Byron-Jackson Company, Patterson - Ballagh, and Falcon Products. He is going to Cairo, Egypt, via London, England, and will service all oil companies in the Near East from headquarters at Baghdad or Busra, Iraq. Many years of practical oil-field experience as toolpusher, driller, and cementing company salesman and executive in California, Oklahoma, and Texas, as well as operating formation tester and cementing equipment abroad for the Iraq Petroleum Company, eminently qualify "Monk" for his new duties.

M. W. Cook

● **W. H. Hales** has been named chief engineer of the manufacturing department of Standard of California. Hales, a 1923 Stanford University graduate, went to work for Standard in 1924 as a construction superintendent at the company's El Segundo refinery. Most of his service with the company since that time has been at El Segundo and at Standard's Richmond refinery. He was made chief engineer of the Richmond plant in 1943. Other manufacturing department appointments also announced include those of **W. H. Spaulding** as assistant chief engineer, and **J. O. Ciprico** as designs engineer. Spaulding joined Standard in 1938 after taking a master's degree at Massachusetts Institute of Technology. He was departmental job engineer prior to his new appointment. Ciprico has worked in various engineering capacities for the company since 1919, after graduation from the University of California.

W. H. Hales

● **Paul Rhodes** is the new purchasing agent for the Hyster Company, Portland, Oregon, manufacturers of lift and straddle trucks and tractor equipment. He has been with the company since September, 1945, working in coordinating and expediting of materials in the Chicago office of the Hyster Company whose three factories are in Portland, Oregon, and Peoria and Danville, Illinois. Previous to joining the Hyster organization, Rhodes worked in the Chicago office of the U. S. Engineers during the war years.

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● **J. M. Evans** has been appointed to the position of chief engineer and chairman of the board of engineers of Standard of California. Evans, assistant chief engineer since 1944, succeeds H. H. Hall, now a director and vice president of Trans-Arabian Pipe Line. Hall continues with Standard as consulting engineer. Evans began with Standard of California in 1915, on graduation from the University of California. After service in World War I, he returned to the company's engineering department in 1920, and since that time has been associated with Standard's engineering and construction work. From 1929 to 1939 he headed the civil engineering division of Standard's engineering department and in 1943 he was made assistant to the chief engineer. Standard also announced three other appointments in its engineering department. **R. W. Parker** and **E. S. Warner** become assistant chief engineers and **A. W. Horton** was made assistant to the chief engineer. Parker, a graduate of University of British Columbia, has been with Standard since 1930. He has been chief engineer of the company's manufacturing department since 1946. Warner, chief designs engineer since 1945, graduated from Yale in 1934, and went to work for Standard two years later. Horton has been supervising engineer in the company's engineering department for the last two years. A graduate of Massachusetts Institute of Technology, he has been with Standard since 1939.

J. M. Evans

● **J. E. Gosline** has been named general manager of producing department by Standard of California. Gosline has been manager of the producing department, southern district since 1943. The son of an oil industry pioneer, he joined Standard in 1933 after taking an engineering doctorate at the University of California. After a few months in the company's general engineering department Gosline was appointed a petroleum engineer in the producing department. He is president of the Petroleum Production Pioneers. **J. H. Thacher,** manager of Standard's gas division of the producing department since 1945, will take over Gosline's former position in Southern California. Other new appointments in Standard's producing department include those of **W. C. Johnson,** who becomes general superintendent of producing department, southern district, and **R. E. Clarke,** who succeeds Thacher as manager of the gas division of the producing department.

J. E. Gosline

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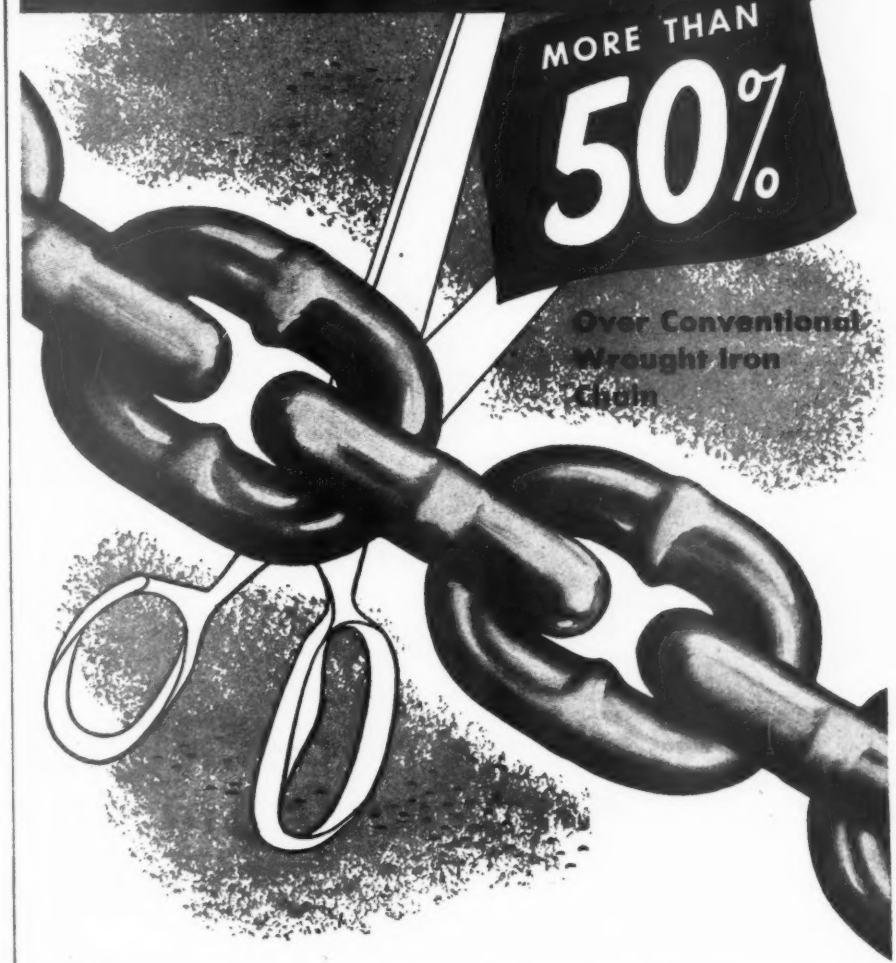

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● **J. L. Cooley** has been elected to the position of vice president and director of California Research Corporation, Standard of California subsidiary. He will be responsible for research on fuels and special products. At the same time, announcement was made of changes in the responsibilities of two other vice presidents. **W. N. Davis** henceforth will supervise research on lubricating products and **L. P. Elliott** will handle process research and engineering. Cooley, a native Californian, is a graduate of the University of California. He joined Standard in 1920 in the engineering department at the oil company's Richmond refinery. Three years later he transferred to the research and development organization serving as distillation and cracking specialist. Subsequently he became technical assistant to the manager of research and development in San Francisco. In 1937 Cooley was "loaned" to the Bahrein Petroleum Company, a Standard affiliate, where he organized the research and development department of that organization. He was appointed associate director of California Research Corporation in 1944 and held this position at the time of his recent appointment.

J. L. Cooley

● **Don E. Fricker** has been made assistant advertising manager of the Heil Company, Milwaukee, Wisconsin. Fricker was in charge of advertising for the LeRoi Company, Milwaukee, prior to his military service. In the army 31 months, he spent 18 months overseas, and handled publicity for soldier shows in Italy.

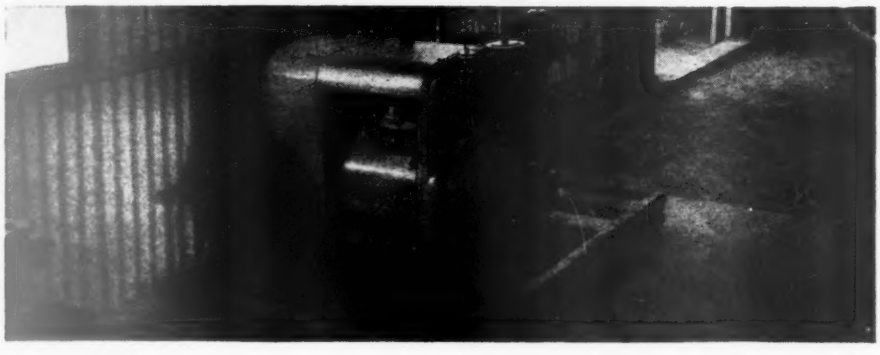
● **John W. Wagner** of Dallas, Texas, has been named public relations director for the Texas Mid-Continent Oil and Gas Association, Charles E. Simons, vice president and general manager announced. Wagner succeeds North Bigbee, the association's public relations director since 1940. Bigbee resigned to do free-lance writing. An University of Texas graduate, Wagner was a member of the capitol press corps at Austin several years before the war, specializing in coverage of the Railroad Commission's oil and gas activities and reporting legislative news. He enlisted in the Army Air Forces shortly after the outbreak of war and was discharged as a major after holding public relations assignments in Europe and at Headquarters, Army Air Forces. Prior to joining the association, Wagner was on the *Dallas News* city editorial staff.

John W. Wagner

● **William C. Kinsolving** has been elected president of the Sun Pipe Line Company (Texas) and the Susquehanna Pipe Line Company. Election of **F. Hill Sanders** as vice president, general manager, and a director of the former company, and of **Sanford E. Ogle** as vice president and a director, also were announced. At the same time, the appointment of **Everett L. Meley** as superintendent of storage and delivery facilities of Sun Oil Company throughout the Southwest was announced. Kinsolving, a native of Corsicana, Texas, joined Sun Oil Company as an oil field hand after receiving a degree in electrical engineering from Cornell University in 1923. He advanced through various stages of oil field work until he was placed in charge of the construction of a products pipe line in the East in 1930-31. Returning to Texas, he directed the construction and the operation of a crude oil pipe line from the newly discovered East Texas field to the Gulf Coast. In 1942 he was called to Washington to serve as assistant director of transportation for the Petroleum Administration for War. In that capacity he figured prominently in the planning and construction of the 1300-mile "Big Inch" pipe line from Texas to Philadelphia and New York. He was later commissioned a colonel in the Army Corps of Engineers and played a prominent role in the building of the China-Burma-India pipe line. Upon completion of his war service in India, Kinsolving returned to Sun Oil Company as manager of all pipe line operations. Sanders joined Sun Oil Company as pipeliner in the Vinton field, Louisiana, in 1932. In 1940 he became district foreman with headquarters at the pipe line terminal on the Mississippi River near New Orleans. During the war he served three and one-half years as a Naval officer and held the rank of lieutenant commander when he left the service in October, 1945. Upon his return to Sun Pipe Line Company, he was appointed area superintendent of the Gulf Coast Division. Ogle joined Sun Oil Company in 1926 to enter foreign service in Venezuela, and subsequently became party chief in the geophysical department. He became an engineer in the East Texas division of the pipe line company in June, 1931. In 1945 he became manager of the engineering department, South Texas division of the Sun Pipe Line Company (Texas). Meley joined the engineering department of the Dallas office of Sun Oil Company in May, 1919. Six months later he was assigned to the purchasing department of the Beaumont office and in July, 1920, was transferred to the Sun Pipe Line Company as assistant pipe line superintendent. He became pipe line superintendent of the Gulf Coast division in 1944.

William C. Kinsolving

WISCONSIN *Air-Cooled* ENGINE
Pumps Air for Engine Starting



At the Anchor Corporation's Eola, Louisiana gasoline plant, this Model VE-4, V-type, 4-cylinder Wisconsin Air-Cooled Power Unit, operating on natural gas, drives an air-cooled compressor (47 C.F.M. @ 250 lbs. pressure) . . . supplying a thoroughly dependable compressed air supply for engine starting.

Built by Harley Sales Company, this unit is typical of Wisconsin Air-Cooled Engine power applications in the oil field . . . delivering the Most H. P. Hours of power service, at the lowest cost per H.P. Hr.

WISCONSIN MOTOR
Corporation
MILWAUKEE 14, WISCONSIN
World's Largest Builders of Heavy-Duty Air-Cooled Engines

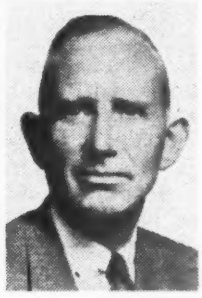
WRITE TO HARLEY SALES CO.
510 Atlas Building, Tulsa, Oklahoma
M & M Building, Houston, Texas
Oil field distributors for Wisconsin Engines and all types of utility units.

To sales posts

Two new appointments to west coast sales positions were announced recently by V. C. Genn, general sales manager of the Detroit Diesel Engine Division, General Motors Corporation.

Lauren H. Wells has been assigned as sales engineer for the northern west coast zone and will direct industrial, marine, and petroleum distributors sales in that area. His territory will include Washington, Oregon, and the northern part of Idaho. Wells joined the General

L. H. Wells



Victor Hansen

Motors organization in 1937 and since that time has been associated with various phases of diesel engineering work.

Victor Hansen will take over the southern west coast zone in a similar capacity with distributors in California, Arizona, and eastern Nevada coming under his jurisdiction. Hansen joined Detroit Diesel from General Motors overseas operations in October, 1946, bringing with him a 20-year record of continuous GM service. Hansen will make his headquarters at Oakland, California.

The appointments of Wells and Hansen were made to fill vacancies left by Murrison C. Wright and James R. Williams who, as of August 1, took over the northern California distributorship franchise for the sale of General Motors Series 71 marine and industrial diesels.

Constructing factory

Economy Electric Lantern Company, Inc., Milwaukee, Wisconsin, now has under construction a new factory and office building at Sturgeon Bay, Wisconsin. The new plant will be ready for occupancy about September 15. In the meantime the company, which manufactures portable lanterns for every purpose under the trade name Ecolite, will continue to serve its customers from its Milwaukee address at 3100 West Cherry Street, it is announced.

Pioneers' barbecue

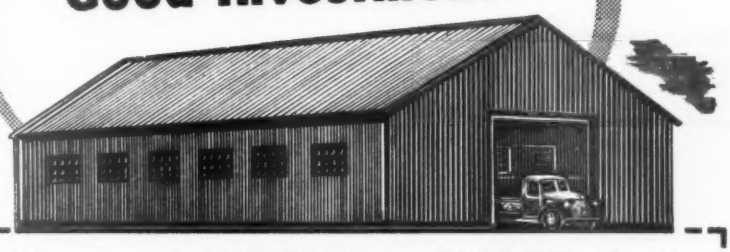
Petroleum Production Pioneers, already numbering 750 members, although one of the industry's youngest organizations, is now completing arrangements for a barbecue on Union Oil Company's picnic grounds, near Brea, on September 13, from 2 to 7 p.m. Chef Frank Romero, popular barbecueist, will preside over the pits, and a record turnout is again expected.

These popular gatherings bring together the outstanding pioneers of the petroleum industry in an orgy of reunion and recollection that seems to satisfy a very prevalent desire of the members. It is a pronounced characteristic of oil men that they like to consort with others of their kind, and these meetings provide an opportunity, which many of the pioneers have long sought, to meet with former associates and friends, and to reminisce under congenial and pleasant circumstances.

Although the open meetings are largely social and informal in character, the Petroleum Production Pioneers has some serious projects under way. The completion of a history of California petroleum, with particular emphasis on the human aspects, is one of the major objectives. This will be preceded by the preparation of a series of graphical sketches of the men who have been responsible for the development of the oil industry, particularly producing and related phases, on the Pacific Coast.

Six hundred members and friends journeyed to Bakersfield for the last outdoor meeting, and indications are that an even larger representation will be found at the southern division locale on September 13. It is planned, according to J. E. Gosline, president, to alternate the picnics in the San Joaquin Valley and coastal areas with those held in Los Angeles district, so that the members in these more distant parts will be able to attend at least one meeting a year without serious inconvenience.

Good Looking!..
Good Engineering!..
Good Investment!



Timeproof ALUMINUM or PLASTEEL sheet Roof and Sidewalls . . . Eliminate periodic painting and maintenance.

Enduring rigid steel frame building. Quickly erected. Economical first cost and low maintenance. A thoroughly engineered structure, mechanically correct. Shipped complete and ready to erect. Like all Soule structural steel products, a good, timeproof investment. Be sure the Soule-way; you'll want to add to it some day. Made in the West for Western needs.

Immediate Delivery—*Shipments made quickly from our Los Angeles plant. Order direct or through your local contractor.*

Size 40-feet by 100-feet—*Can be furnished longer or shorter in 19'-9" sections. Add any time in any direction without damage to first unit. 12-foot by 14-foot high door. Full 14-foot head room at eaves with vertical sidewalls; no interfering interior columns.*

Rugged Design—*Designed to meet uniform building codes covering live and dead loads, high winds, earthquakes, etc.*

Send coupon today for plans and prices

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SOULÉ STEEL COMPANY
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Without obligation, send Catalog No. 200 and prices covering the 40' by 100' Soulé Utility Steel Building . . . also furnish free foundation plans for use by my local contractor.

Name _____
Address _____
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Soulé Utility STEEL BUILDINGS

SAN FRANCISCO • LOS ANGELES • PORTLAND

FABRICATORS OF STEEL BUILDING PRODUCTS SINCE 1911

EXCLUSIVE
PATENTED
FLEXIBLE
TUBING SWAB

4-Cup Assembly

Pulls More Fluid Per Round Trip Than Any Other Swab

Reversible Swab Cups Give Double Life

2-Cup Assembly Can Be Unjointed Here

Flexible Swab Goes Through Curved Pipe

Wrench Can Be Used On Solid Center

Large By-Pass for Flow Through Swab

- Advantages of the 4-cup assembly of the BELL FLEXIBLE TUBING SWAB are its flexibility and the REVERSIBLE CUPS which give double life for the price of one.
- After many years of research and exhaustive tests in oil wells of various depths in many types of abrasive conditions, the BELL REVERSIBLE SWAB CUPS have repeatedly made more trips than any other swab on the market.
- The BELL TUBING SWAB is a tested . . . proven . . . long-wearing . . . dependable tool . . . commended by the men in the field after many rigid tests.
- Available in 2" and 2½" sizes . . . Standard 2-cup and Flexible 4-cup assemblies.

MECHANICAL
MANUFACTURING CO., INC.
M-M
2720 BRYAN STREET
PHONE 4-3261
FORT WORTH, TEXAS

Teacher: Johnnie, do you want to leave the room?

Johnnie: Say, teacher, you don't think I'm standing here hitch-hikin', do you?

* * *

In one crowded Chicago night club recently an escort stooped to pick up his gal's glove and before he could straighten up a waiter had thrown a tablecloth over him and seated five people.

* * *

Rastus: Say, Sambo, what time in yoah life does yo' think yo' wus scared de worstes?

Sambo: One when ah wuz callin' on a married gal and her husban' came in and caught me. Boy, wuz ah scared!

Rastus: How are you' shuah dat wuz de worstes time?

Sambo: 'Caus her husban' turned to dat wife of his an' says, "Mandy, what's dis white man doin' heah?"

* * *

"How did you find the ladies at the dance?"

"Oh, I just opened the door marked 'Ladies' and there they were."

* * *

Patient: "Why stick me in the room with that crazy guy?"

Doctor: "The hospital is crowded. Is he troublesome?"

Patient: "I'll say. Just keeps looking around saying, 'No lions, no tigers, no elephants'—and all the time the room's full of them."

* * *

"Papa, there's a woman peddler at the door."

"Tell him to beat it. I got one too many already."

* * *

The trouble is that when success turns a fellow's head, it doesn't wring his neck at the same time.

* * *

I always wondered where all the Smiths came from till I came to this city. Then what happened? I saw a sign: "Smith Manufacturing Company."

* * *

A bathing beauty is a girl who is worth wading for.

* * *

Time tells on a man—especially a good time.

* * *

A guy wandering through a department store squeezed one doll and it cried "Mama." Later he squeezed another doll and it screamed: "Floorwalker."

* * *

"Do insects ever get in your corn, Farmer Jones?"

"Yep, but we just fish 'em out and drink it, anyway."

"I can't quite diagnose your case. I think it must be drink."

"All right, doctor, I'll come back when you're sober."

* * *

"What happened to that girl you used to take out? She had a figure as trim as a sleek ship."

"She did, but her cargo shifted."

* * *

Returned Soldier: Yes, the blonde ran up to me, and threw her arms around me, and kissed me. Can you imagine how I felt?"

Ditto Friend: Sure I do. You felt to see if your purse was still in your pocket."

* * *

A tavern keeper was awakened in the early hours of the morning by some heavy pounding on his front door. Putting his head out the front window, he shouted:

"Go away. You can't have anything to drink at this hour."

"Who wants anything to drink?" was the response. "I left here at closing time without my crutches!"

* * *

Porter: Did you miss your train, Sir?

Irate Traveler: No, I didn't like its looks, so I chased it out of the station.

* * *

"When I was a farmer I bough' two rabbits and two years later I still had two rabbits. How was I to know they were brothers?"

* * *

"Afraid?"

"Not if you take that cigar out of your mouth."

* * *

Two men were knocking another. "To me," said one, "he's a pain in the neck." "Funny," said the other. "I had a much lower opinion of him."

* * *

Purchasing Agent: Are you sure your wife knows you're bringing me home to dinner?

Young Salesman: Does she know? We argued about it for half an hour this morning!

* * *

The moron took some insect powder with his aspirin because he had such a lousy headache.

* * *

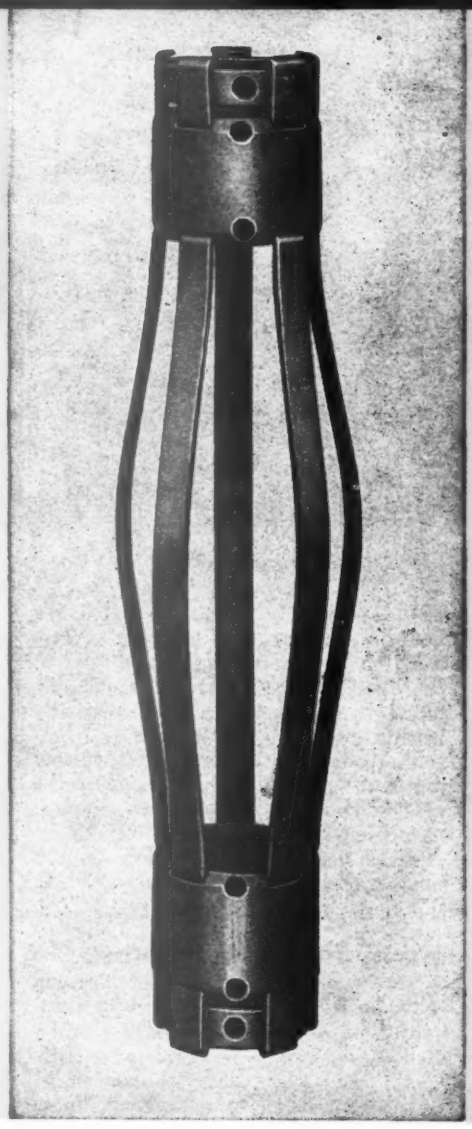
Count: I hear he drinks something awful.

No Count: Yeah, I tasted it.

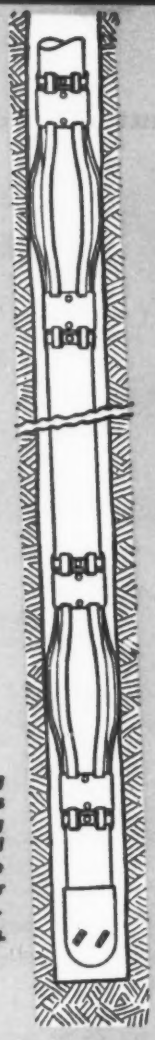
* * *

The surest way to tell a male sardine from a female sardine is to watch and see what can they come out of.

Casing hanging vertically in a hole that is slightly off vertical contacts the hole at points "A" and "X". This is a frequent cause of cementing failure.



Use of Baker Casing Centralizers insures centering of casing in the hole at all critical points—the ideal condition for successful "first-time" cementing.



IT PAYS TO CENTER CASING

When casing is off-center and leaning against the side of the hole at the shoe joint (left view above) the hazard of channeling is obvious. It is also easy to see why so many cementing jobs are failures because it is impossible to place a uniform body of cement ALL AROUND the casing at the vital shoe joint when the casing is not centered. So long as this condition exists, there are sure to be failures to secure good water shut-offs as well as other cementing failures.

Now let's study the drawing at right which illustrates how Baker Casing Centralizers (Product No. 910) provide a uniform annulus for placement of cement entirely around the casing at critical cementing points, and minimize the danger of channeling. Baker Casing Centralizers are simple and effective; they are easy to install and use; they are inexpensive and can be secured promptly through your nearest Baker office or representative.

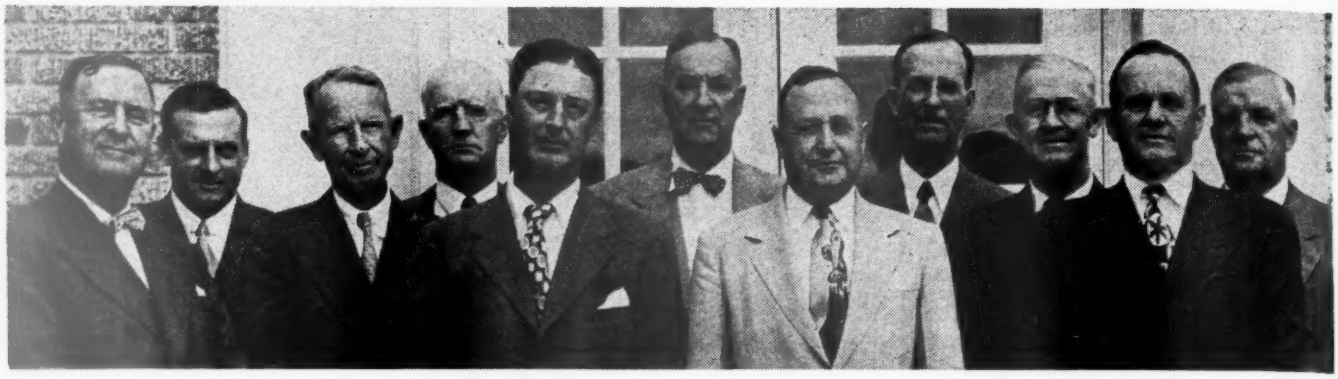
BAKER OIL TOOLS

It's Time to Center YOUR Casing!

If you would like a copy of the New BAKER Casing Centralizer Broadcast, which describes and illustrates many important applications, address Baker Oil Tools, Inc., Box 127, Vernon Station, Los Angeles 11, California.

BAKER OIL TOOLS, INC., LOS ANGELES • HOUSTON • NEW YORK

Wyatt officials attend quarterly meeting



Officers and directors of the Wyatt Metal and Boiler Works recently attended the regular quarterly meeting of the board of directors held in Houston, Texas. After the meetings, directors inspected Wyatt's Houston plant and office facilities, which have been modernized and greatly expanded during the past several months. It was the first board meeting in the history of the company to be held in Houston. All previous meetings have been held at the Dallas offices.

Officers and directors shown in the photograph are from left to right: H. P. Willard, director, Dallas; Frank E. Austin, Jr., director, Dallas; J. Warren Jones, director, Dallas; W. H. Dwyer, Sr., director, Dallas; Walter B. Van Wart, executive vice president, Houston; Henry R. Davis, vice president, Dallas; Raleigh Hortenstine, president, Dallas; C. R. Moore, vice president, Dallas; Guy Gambrell, secretary and treasurer, Houston; George E. Gude, Jr., vice president and manager of sales, Houston, and Ralph W. Malone, assistant secretary and treasurer, Dallas.

ATTENTION-
money minded
ENGINEERS

Engineering and money are inseparable. That's why a good engineer always considers costs when recommending the purchase of equipment.

And that's why engineers usually recommend Jensens. They know Jensens are conservatively rated, ruggedly built, have a low initial cost and practically no upkeep. In other words it's good engineering to know all about Jensens.

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Kirkpatrick succumbs

Crawford Neal Kirkpatrick, chairman of the board of the Landis Machine Company, Inc., of Waynesboro, Pennsylvania, died at his home in Waynesboro on July 28 at the age of 57 years after an illness of several months.

C. N. Kirkpatrick

Kirkpatrick was well known in the machine tool industry and in the metal trades, where he was highly regarded for his progressiveness and leadership. His entire working life of 34 years was spent with the Landis Machine Company.

Starting work in the shipping department during his school vacations, he entered the sales department upon his graduation from Dickinson College in 1913. Through his forceful energy, Kirkpatrick rose rapidly to an executive position, and successively held the positions of sales manager, secretary, general manager, vice president, and upon the death of the late J. G. Benedict in 1942 was elected president of the company. Due to ill health he was compelled to relinquish his active duties and in March, 1947, was elected chairman of the board. He also served as secretary of the Canadian Landis Machine Company, Ltd. of Welland, Ontario, a wholly owned subsidiary, as well as a director of both the home and Canadian companies.

Warehousing Aristoloy

"The Flint Steel Corporation (formerly Tulsa Boiler & Machinery Company) of Tulsa, Oklahoma, announces that it is now warehousing Aristoloy alloy steel bars, effective July 1. Aristoloy is the trade name of electric furnace steels produced by the Copperweld Steel Company, Warren, Ohio.

Heads association

Robert F. Carter, general construction superintendent of The Lummus Company, New York, has recently been elected vice president of the National Constructors Association.

Robert F. Carter

Carter was in the engineering business as a consultant and in construction work prior to his joining The Lummus Company. While with The Lummus Company, he has filled the capacity of operator, job engineer, and superintendent on both domestic and foreign work. He has recently been made general construction superintendent, in which capacity he has charge of all construction work for the company.

To manage plant

The H. K. Porter Company, Inc., has appointed John F. Cunningham, Jr., as manager of the J. P. Devine Manufacturing Company Plant at Mount Vernon, Illinois, it is announced by C. R. Dobson, vice president in charge of operations.

Cunningham, formerly was research engineer and manufacturing division engineer for the Elliott Company, Jeannette, Pennsylvania, during the development of the first gas turbine power plant built in America.

ARMSTRONG BROS.

CHAIN TONGS

"ARMSTRONG BROS." Chain Tongs come in "Standard," "Reversible Jaw" and "Ideal" (V-jaw) types—in sizes for every need. Their drop-forged jaws have milled teeth, are hardened, tempered and tested for wearing qualities. They have heavy forged-in lugs that give extra bearing on the handles to which they are rigidly held by a large hardened steel bolt. The handles are forged and heat treated to the correct balance of stiffness and spring. Shackles are drop forged and chains proof-tested to ⅔ catalog strength (3,600 lbs. to 40,000 lbs.).

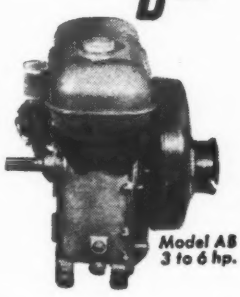
Write for Chain Tongs Circular

ARMSTRONG BROS. TOOL CO

331 N. Francisco Ave.,
Chicago 12, U.S.A.

New York
San Francisco

BEE-LINE ENGINES



Model AB
3 to 6 hp.

Model BB
2.5 to 4.3 hp.

In Volume Production

Prompt Delivery

These 4-cycle, air-cooled gasoline engines are thoroughly service-proved in many applications. Light weight, compact design, and wide power range mean ready adaptability to many types of equipment and powering problems. Backed by 28 years of engine building experience, including manufacture of the famous Kinner aircraft engines.

Gladden Products CORP.

635 W. Colorado Blvd., Glendale 4, Calif.

California sales manager

The appointment of C. S. "Cliff" Divelbiss as California sales manager has been announced by Patterson-Ballagh. Cliff has worked in the oil fields since 1925, four years for the Standard Oil Company and 14 years in oil-well cementing. He has represented Patterson-Ballagh as a field man in the Los Angeles

R. W. Shira

C. S. Divelbiss

Basin for the last three years and is well known throughout the California fields.

R. W. "Bob" Shira, formerly advertising and sales promotion manager for the firm, will take over Cliff's duties in the Los Angeles Basin. From 1938-42, Bob was in the sales department of the Hughes Tool Company in California. He left to serve Uncle Sam in Canada and Alaska, returning to Hughes in November, 1945. Since June, 1946, he has been handling advertising for Patterson-Ballagh. Bob has many friends throughout the industry who will be glad to see him active in the field again.

Joins Ransome Machinery

Ransome Machinery Company, a subsidiary of Worthington Pump and Machinery Corporation, has recently appointed Allan B. Kime eastern regional manager in charge of the sale of Ransome positioning and turning roll equipment.

An electrical engineer, Kime has had extensive experience in both the production and sales end of the welding field, having been associated for the last 12 years with the Federal Shipbuilding and Drydock Company, Kearny, New Jersey, in a supervisory capacity in charge of welding production methods and procedures. He was formerly sales engineer in the New York metropolitan district for both the Century Electric Company and the Lincoln Electric Company, and has been a member of the executive committee of the New Jersey section of the American Welding Society.

Kime's eastern regional headquarters will be at the Ransome Plant, Dunellen, New Jersey.

Bibliography error

In *The Petroleum Engineer's* 1947 Reference Annual, page 315, in the bibliography of papers given in 1946-47, the author of "Results of Experimental Water Flooding in the Haynesville Field, Pettit Zone, a Lime Reservoir Originally Under Dissolved Gas Drive" is listed as "O. S. Ervub." This is a typographical error. The name of the author is P. S Ervin, who is a petroleum engineer with the Haynesville Operators Committee, Haynesville, Louisiana.

PUMPS for PETROLEUM PRODUCTS

Write for Bulletin 102—Pumps for the Petroleum Industry

It will tell you why

BLACKMER ROTARIES

are SELF-ADJUSTING FOR WEAR

GATHERING PUMPS
REFINERY PUMPS
BULK STATION AND TRUCK PUMPS
HAND PUMPS
SUCTION LINE STRAINERS

Capacities to 750 GPM.
Pressures to 300 psi.

BLACKMER PUMP COMPANY
1980 Century Ave., Grand Rapids 9, Mich.

SERVING THE PETROLEUM INDUSTRY FOR 40 YEARS

DEVELOPED
In a Laboratory

PROVED
In Power Plants

With a 20-year record for promoting power production.

SAND-BANUM

Automatically and in absolute safety to personnel and equipment removes and prevents boiler scale and corrosion, regardless of water or operating conditions.

All You Do

is to apply just a few ounces once a week. 1—16-oz. can, all active ingredients, protects 1—250-hp. boiler for 1 month. Write for proof; accept our invitation to make your own test.

"The Entirely Different Boiler and Engine Treatment"

AMERICAN SAND-BANUM COMPANY, Inc.
9 ROCKEFELLER PLAZA,
NEW YORK CITY 20

Field test

Approximately 75 professors of mechanical engineering from the leading colleges in the United States recently witnessed a field test run of International Harvester Company's giant new TD-24 crawler tractor during a day-long session at the company's diesel engineering facilities in Chicago.

The demonstration was part of a program sponsored in connection with a week-long "Conference of Teachers of Diesel Engineering" held in Chicago under the auspices of the Diesel Engine Manufacturers' Association.

Interested in advance engineering and in new training aids that could be applied to teaching methods in their respective colleges, the educators toured the company's large industrial plant to study these various engineering procedures.

Considerable interest was focused on the engine of the new 36,000-lb TD-24 tractor because of its vast horsepower capacity for tractor use and the significance it will have on future development of similar engines.

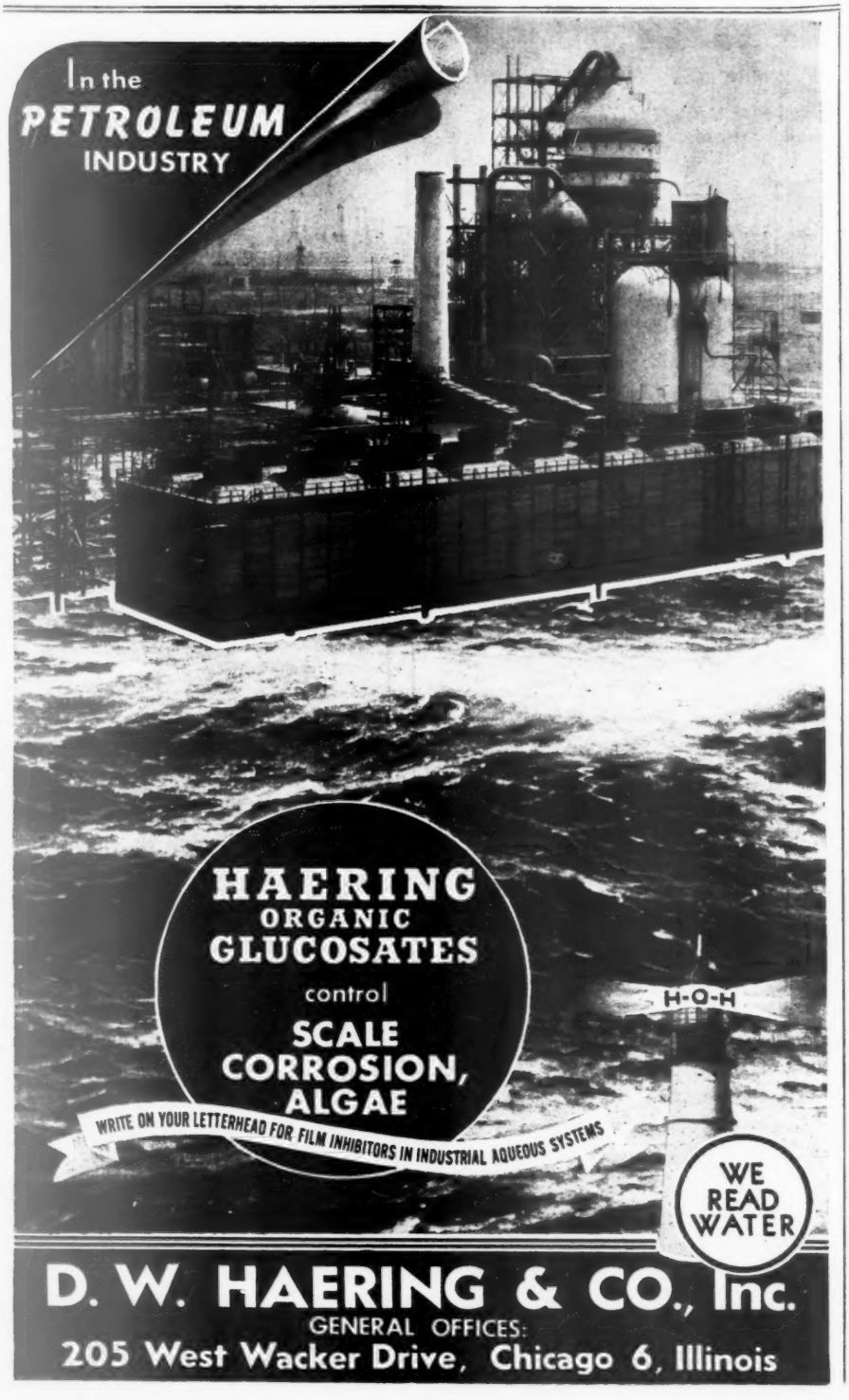
"Primary objective of this conference," commented H. T. Reishus, general manager of the Melrose Park plant, "was to assist educators in developing able, well-trained mechanical engineers to design, build, sell, and install diesel engines."

Sales engineer

V. C. Genn, general sales manager of the Detroit Diesel Engine Division, General Motors Corporation, has announced the appointment of Royce A. Hill as field sales engineer for the northern section of the division's Dallas region. Hill, in his new assignment, will be responsible for all industrial and petroleum distributors' sales activities for the territory, which includes Oklahoma, northern Texas, and northern New Mexico. This jurisdiction will also cover the upper part of Louisiana for petroleum sales distributors only.

Royce A. Hill

Since joining the Detroit Diesel organization in October, 1944, Hill has served in various sales capacities including assistant to the overseas sales manager, which post he has held for the last several months. The appointment of Hill was made to fill a vacancy left by Fred L. Manton who has taken the position of sales manager with the Diesel Power Company, distributors for General Motors Series 71 engines in the State of Oklahoma.



SITUATIONS OPEN: Chemical Engineers with three to five years' experience in the operation of petroleum refining distillation units, thermal cracking units or catalytic cracking units for work as Technical Service representatives and Operators of commercial catalytic cracking plants. Kindly send details of experience and education. Snapshot (if available). Address Box No. 59, % *The Petroleum Engineer*, P. O. Box 1589, Dallas, Texas.

MAGNETO TELEPHONES

for construction jobs, mines, oil wells, country homes, estates, etc. Permanent or temporary installations. Also wire, insulators, ground rods, batteries, and other necessary equipment. Prompt Delivery. TELEPHONE REPAIR AND SUPPLY COMPANY, 1760 Lunt Avenue—137, Chicago 26, Ill.

WANTED: PETROLEUM ENGINEERS (graduates preferred, but not necessary) in all major producing areas for field work in core analysis and drill cuttings analysis. Apply by letter only. Send full particulars on education and business experience to

CORE LABORATORIES, INC.
Box 5810
Dallas, Texas

District sales manager

Appointment of Addison Y. Gunter as southwestern district sales manager for the Alco Products Division of the American Locomotive Company has been announced by Hugh M. Corrough, director of the Alco Products Division. Gunter will make his headquarters in Houston, Texas.

Addison Y. Gunter

Gunter, a graduate of Texas A. & M., has been associated with the Alco Products Division since 1937. He served as production engineer, chief operations engineer, director of development, and assistant manager of sales and engineering prior to his new appointment.

Before joining American Locomotive, Gunter served 12 years with the Empire Oil and Refining Company and Cities Service Oil Company in Tulsa, Ponca City, and East Chicago, being assistant manager of the refinery at East Chicago.

Made sales engineer

American Car and Foundry Company announces the appointment of Lloyd H. Mulbarger as sales engineer in the New York sales office.

Mulbarger was born in Lima, Ohio, and educated in the Lima and Cleveland schools. His special training at John Huntington Polytechnic Institute, Cleveland, Ohio, included machine design, applied mechanics, and sales engineering.

He began his career with the Nickel Plate Railroad at Lima, Ohio, as an apprentice in 1926. In 1929 he was transferred to the engineering department at Cleveland as a car draftsman. Two years later he was transferred to the advisory mechanical committee of the Chesapeake and Ohio, Erie, Nickel Plate, and Pere Marquette railroads. He then advanced to leading draftsman, assistant chief draftsman, and later chief draftsman, which position he held at the time of his joining the American Car and Foundry Company.

Contractor's meeting

Plans are nearing completion for the 1947 convention of the American Association of Oilwell Drilling Contractors' Convention to be held at Long Beach, California, October 13, 14, and 15. J. E. Warren, president of the association, recently made a hurried trip from Midland, Texas, to California to check with the various committee chairmen on the convention's progress.

The chairman of the housing committee, D. H. Graham, of Dunlap and Graham, Long Beach, and his assistant, Bob Cook of Security Engineering Company, Inc., have the hotel reservation problem well under control and want to assure the out-of-state delegates that if they will get their reservations in reasonably early they will have absolutely no difficulty in getting the type of accommodations they wish.

The California chapter of the American Association of Oilwell Drilling Contractors is making a special appeal to the wives of the members to attend this year's convention. The entertainment committee has many pleasant surprises for the ladies, as well as the active members. Included in the affairs particularly arranged for the wives, is a trip to the Hollywood movie studios. Attractions for the men include a barbecue, manufacturing plant visitations, Long Beach Harbor inspection trips as guests of the Long Beach Harbor Department, luncheons, and banquets.

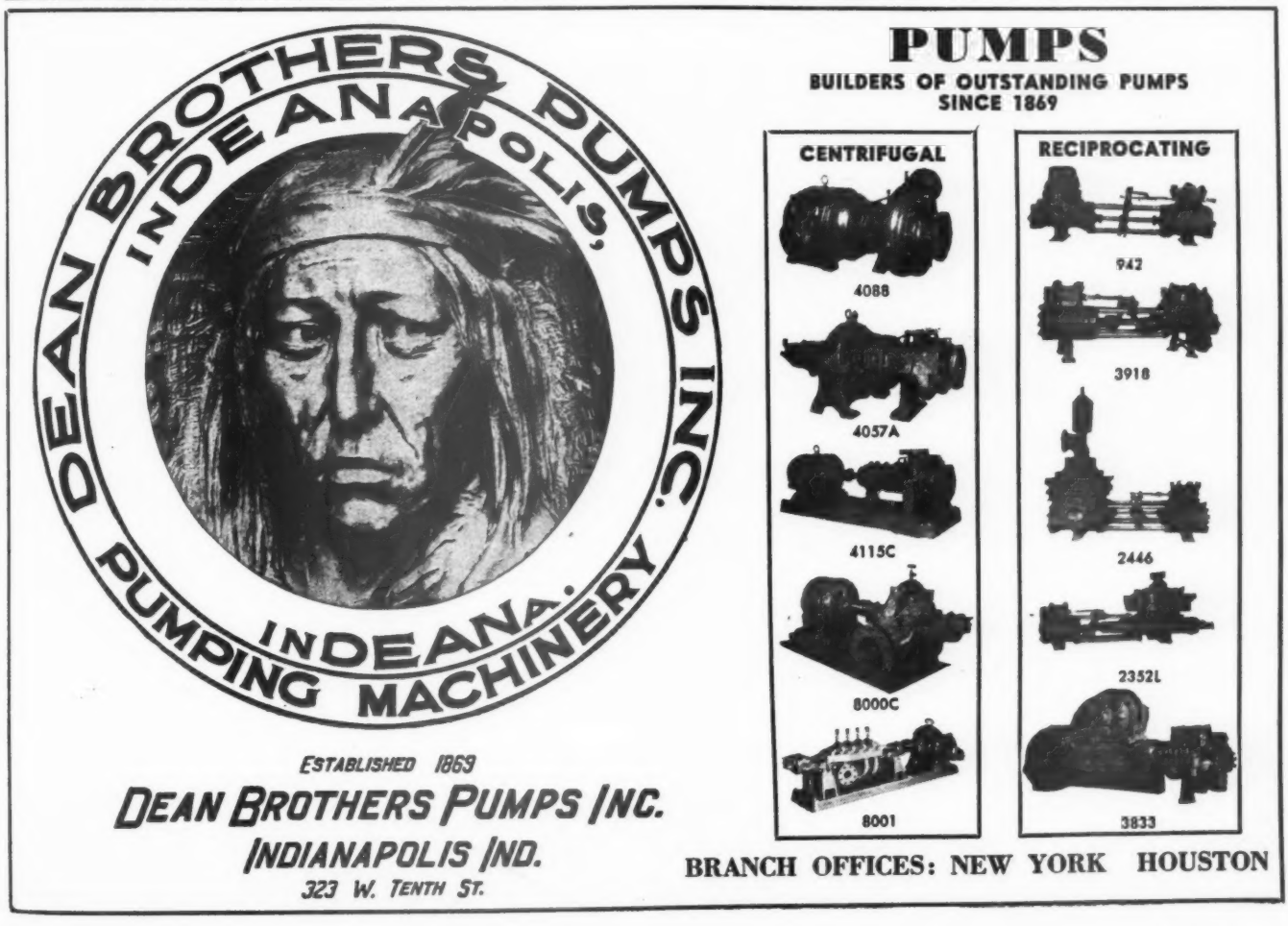
New Elco head

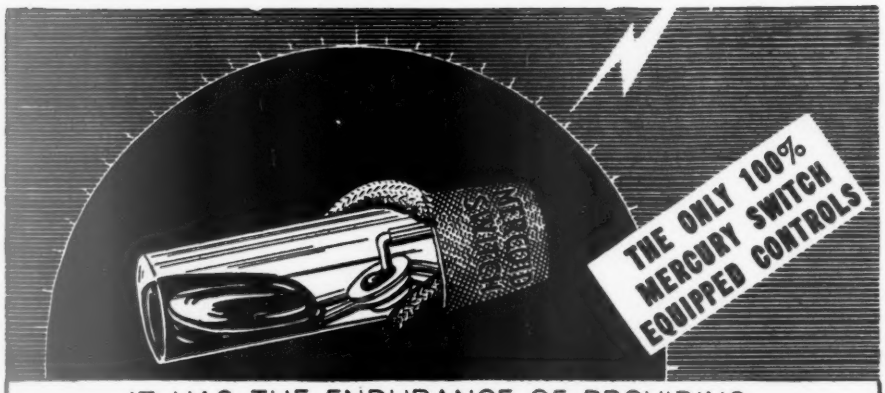
At a special meeting of the board of directors of The Elco Lubricant Corporation, Cleveland, Ohio, held June 24, J. E. Reagan was elected president of the corporation to succeed Wm. Cox, Jr., as of July 1. Cox will continue an active connection with the corporation as member of the board of directors and consultant, and will devote a major portion of his time to development and research.

Office change

The New York export office of Baker Oil Tools, Inc., is now at 11 West 42nd Street, Room 2640, New York City 18, New York. The telephone is Longacre 5-6880—Extension 15. Russ. V. McIntire is in charge as export manager.

Other export officers are maintained in Houston and Los Angeles.





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New officers

The election of O. E. "Ted" Murrey to succeed F. E. Stanley as president of Midwestern Engine and Equipment Company, Inc., has been announced by the directors of the Tulsa firm, who at the same time announced Stanley's resignation. Simultaneously, the directors announced the election of Armon H. Bost as vice president and general manager, G. O. Glandon as vice president and secretary-treasurer, and Joe Hair as assistant secretary-treasurer.

O. E. Murrey

A. H. Bost

G. O. Glandon

The resignation of Stanley, well known in business, civic, and agricultural circles, will enable him to devote his full time to the operation of Midwestern Constructors, Inc., of which he is president, and to other interests. As in the past, Midwestern Engine and Equipment, distributors of general contractors' pipe-line and oil-field contractors' equipment, will continue to be independently owned and operated, with no intercompany relations with any other firm.

As officers of Midwestern Engine and Equipment Company, Inc., since its organization, Murrey, Bost, and Glandon all have widely diversified backgrounds. Murrey, after 13 years' experience in all phases of pipe-line construction, served for seven years as sales manager for the pipe-line department of the Cardwell Manufacturing Company of Wichita, prior to joining Midwestern. He will continue to act as sales manager.

Bost has had extensive experience in the public utilities, pipe-line, and oil industries. During the war he served for five and a half years on the General Staff, U. S. Army, being separated as a colonel. Glandon is well known in the general contracting business, both nationally and in foreign countries. Hair, also with the company since its origin, has served as accountant and office manager for the last year.

The Tulsa firm has warehouses in Chicago, Houston, Oklahoma City, and Tulsa, with a newly opened branch office in Oklahoma City.

District sales manager

The Leyman Manufacturing Company, Cincinnati, Ohio, announces the appointment of Dean F. Gunby as the Houston district sales manager for Mc-

Cowan pumps and Kodweld products. Stocks of pumps and spare parts will be warehoused in Houston. Gunby also will have complete charge of facilities for servicing petroleum and industrial requirements in the Southwest. The offices of the Leyman Manufacturing Company are in the Jameson Building, 1903 Blodgett Street, Houston, Texas.

California Representative

L. L. Rector, president of Rector Well Equipment Company, has announced the appointment of R. M. Bolieau as California representative with headquarters in Tulare. Bolieau entered the oil business in 1928 with Axelson Machine Company. For the last 19 years he has been Mid-Continent and Rocky Mountain representative for the D + B Division of Emsco Derrick and Equipment Company.

President Stokes Rubber

Fred Schluter, president of Thermoid Company of Trenton, New Jersey, announces the election of L. R. Leaver as president of the Thermoid subsidiary, Joseph Stokes Rubber Company, Ltd., Welland, Ontario, Canada. Heretofore Leaver has been a vice president and director of the enterprise.

Leaver has been a resident of Welland, Ontario, for a number of years where he has been managing the Canadian subsidiary. At one time in the early 30's, he was a vice president of Thermoid Company. He has been directing head of Joseph Stokes Rubber Company, Ltd., for more than eight years.

W. D. Pardoe of Yardley, Pennsylvania, was elected a director of the company. Schluter continues as chairman of the board of directors, which includes L. J. Falkenhagen and L. R. Leaver, both of Welland, Ontario, Canada.

Heads company

E. V. Murphree, executive vice president, has been elected president of the Standard Oil Development Company, central research organization of the Standard Oil Company (New Jersey) to succeed Robert P. Russell, who is resigning to become technical consultant to International Basic Economy Corporation of 30 Rockefeller Plaza, New York.

Murphree, who joined Jersey Standard 17 years ago, has contributed to many of the company's technical developments. These include the fluid catalytic cracking process, which made possible enormous increases in the output of 100-octane gasoline for war planes; a process for synthesizing toluene that enabled unprecedented output of this component of TNT at one-fifth the cost of toluene produced from coal; a catalytic process for making butadiene from petroleum for synthetic rubber, a process that resulted in the production of 90 per cent of the wartime butadiene made from petroleum in the United States.

Murphree was born November 3, 1898, in Bayonne, New Jersey. After graduation from the University of Kentucky where he won all-Southern conference selection as a tackle in his senior year when he was team captain, he coached the football team and taught in Paris, Illinois, high school for a year and then became a staff assistant at the Massachusetts Institute of Technology.

After six years of chemical engineering work, Murphree joined Standard (New Jersey) in 1930 as director of a new technical group engaged in developing chemical processes from petroleum raw materials. Within two years he became director of research and development at the Esso Laboratories in Baton Rouge, Louisiana, and in 1934 was elected vice president and a director of the Hydro Engineering and Chemical Company, a Jersey Standard affiliate in New York. He succeeded to the post of manager of research and development for the Development Company in 1936, was appointed vice president in 1938, and became executive vice president in 1946.

Russell, who joined the Standard Oil Development Company in 1927, became vice president in 1934 and president in 1944.

For outstanding service during the war, particularly in the Development Company's work in the fields of flamethrowers, incendiary bombs, and smoke generators, Russell received the Medal of Merit, highest United States award to a civilian, and the Medal of Freedom for conspicuous services in connection with military operations in a war theatre.

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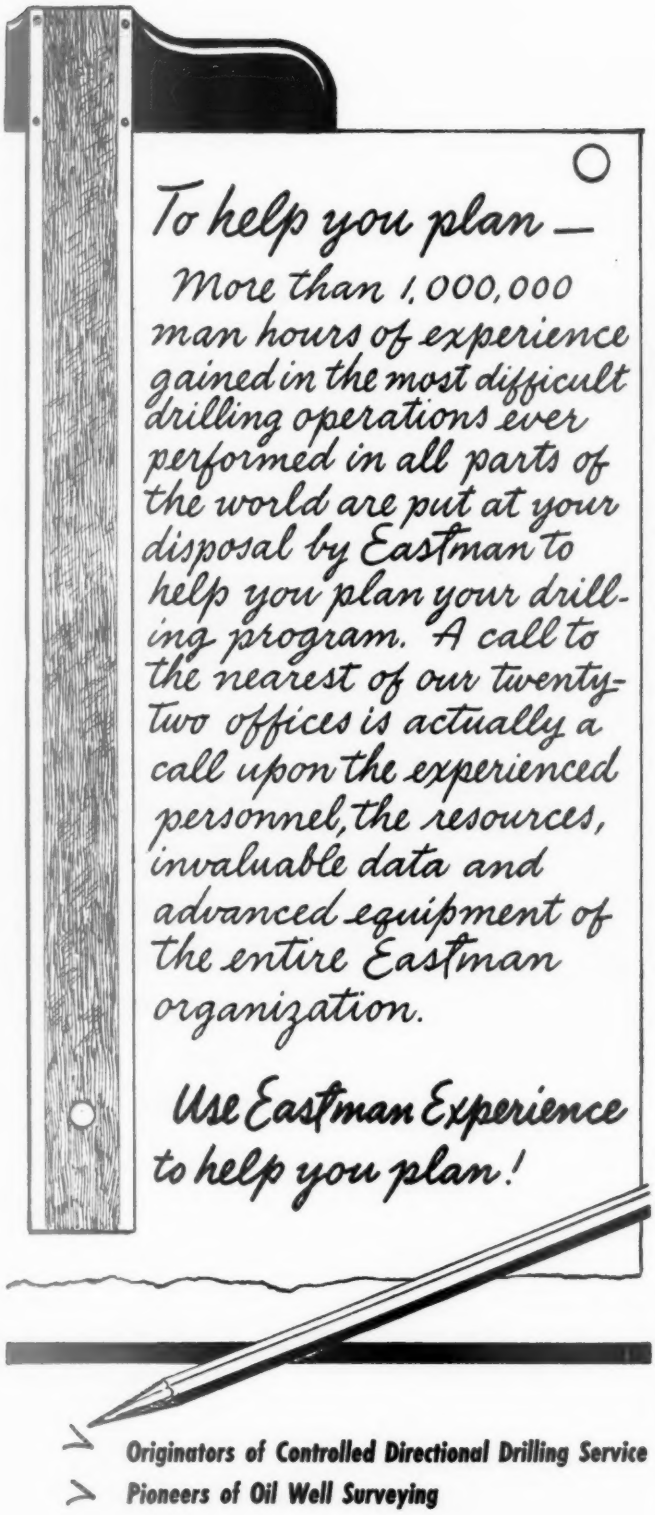
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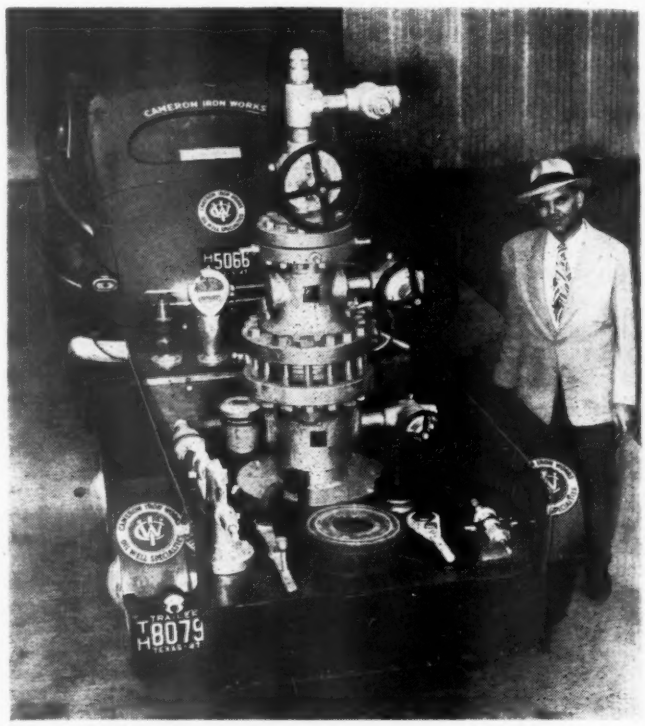
Cameron's oil show on wheels

To better acquaint the man in the field with Cameron equipment, Roy Bean, sales engineer for Cameron Iron Works of Houston, has outfitted a special built trailer that can be towed to the field for on-the-spot demonstrations of Cameron products.

A complete Cameron forged steel Christmas tree, casing and tubing hangers and strippers, a new casing seal flange, two types of flow wings, shear-relief valve, mud line pressure gauge, flex-seal mud line valve and weight indicator, are listed as the products displayed in the unique trailer. All units are actual



size and a number of them shown in section so that their mechanical design can be studied and their operation more readily understood.

"The design of oil field equipment changes rapidly, particularly wellhead equipment, and it has been difficult to keep the industry adequately informed of these changes," said E. L. Lorehn, vice president and general manager of Cameron Iron Works.

"Our oil-show-on-wheels was designed primarily to enable our sales staff to better introduce our new line of Cameron forged steel casingheads, tubingheads, and flow wings; however, this method of displaying our products offers so many advantages that it has been adopted permanently to demonstrate new and improved Cameron products to the trade," said Lorehn.

Bethlehem to new building

The consolidation of the Tulsa general office of the Bethlehem Supply Company and the district sales office of Bethlehem Steel Company, which was effected recently by occupancy of the Bethlehem Building at East Second Street and South Boston Avenue, was announced by G. A. Tompson, vice president of the supply firm.

The office force, formerly in three locations, are now centralized, thus permitting expansion of Bethlehem's Tulsa plant office, which now occupies the building at 905 East Archer Street.

The Bethlehem Building was purchased in 1946 as a part of the company's expansion program, which, in addition to the purchase and remodeling of the downtown Tulsa structure, included enlargements and improvements to both the Tulsa and Corsicana manufacturing plants.

Tompson said the building, formerly known as the Central Building, has been completely modernized.

Marley promotions

Ray T. Jenkins has been promoted to assistant general manager of the Marley Company, Inc., Kansas City, Kansas, manufacturers of cooling towers, nozzles, and other water cooling equipment.

Jenkins entered the Marley organization in 1933 as sales engineer, and since then has headed the Dallas, Texas, and Houston offices and has served as general sales manager since 1944 when he came to the Kansas City office.

Lyle A. Christensen has been promoted to general sales manager of the Marley Company, it is also announced. Christensen served as sales engineer in the New York office of the Marley Company for five years before assuming his new position at home office.

R. T. Jenkins

L. A. Christensen

Before joining the Marley Company he was sales engineer for the Ingersoll-Rand Company for 12 years. Christensen received his degree in mining engineering from Minnesota University.

Change announced

Wailes Dove-Hermiston Corporation, subsidiary of Koppers Company, Inc., has ceased to do business as a separate corporation and is now operating as a part of Koppers Company, Inc. The Wailes Dove organization has taken over all the protective coating business of the Tar Products Division and is now known as the Wailes Dove-Hermiston Department. Linden Stuart heads the department and William Thornhill continues in charge of sales. The Wailes Dove-Hermiston plants will continue the production of its present products.

New assignments

Four new personnel assignments within the distribution division of the Cummins Engine Company, Inc., Columbus, Indiana, have been announced by L. W. Beck, general sales manager.

S. J. Coffey, former manager of Cummins Diesel Sales Corporation of Illinois, has been appointed manager of regions. He will work directly under the general sales manager in supervising the activities of the Cummins regional offices.

Coffey joined Cummins Diesel Sales Corporation of Illinois four years ago as office manager, later serving as sales manager and then manager.

Byron A. Duling has been appointed manager of engine distribution with headquarters at Columbus. In this capacity, he will have charge of all engine distribution to Cummins dealers and to manufacturers who use Cummins diesels to power their equipment.

Duling has been a Cummins employe since 1936, having served as a sales engineer and later as manager of the Cleveland office.

Raymond Boll has been appointed assistant manager of the Cleveland region, with headquarters at 805 Fidelity Building, Cleveland. Boll served with the Army Signal Corps in the Philippines and Japan. He was released as a Captain late in 1946 and returned to the Cummins sales department where he was employed before his military service.

The appointment of W. C. Phillips as assistant manager of the southeastern region also has been announced by Beck. Phillips has been a member of the Cummins organization since 1935, having been a field representative, statistician for the service department, and sales engineer. As assistant to Regional Manager C. A. Buxton, he will make his headquarters at Columbus.

New store

Houston Oil Field Material Company, Inc., announces the opening of another service store at 2800 Southeast 29th Street, Oklahoma City Oklahoma. Raymond E. Alford is store manager, Russel Yost, Bob Acuff, and G. Q. Pool are fishing tool operators, and Joe Zackery is store man. This store will serve both fishing tools and directional drilling.

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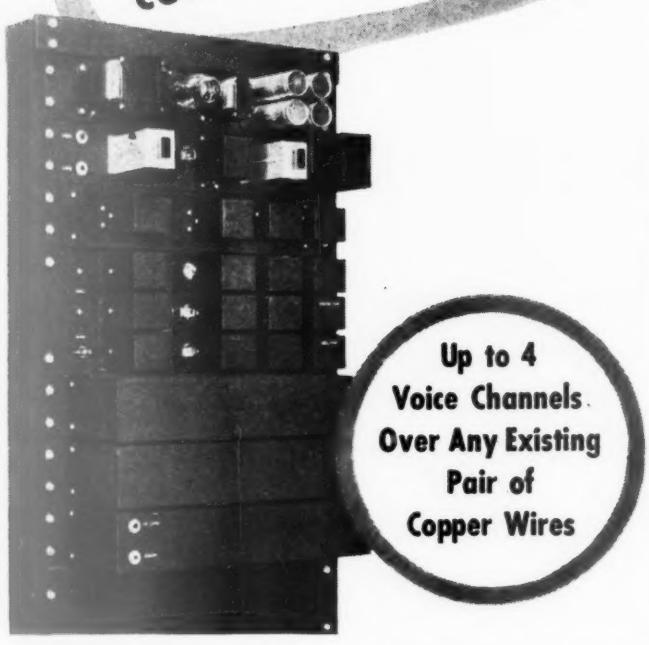

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Pacific Personalities

Just south of the highway that runs between Taft and Bakersfield is a sizeable expanse of navigable water, colorfully known as Lake Buena Vista. Motor boats and small craft ply this juvenile Mediterranean as though they were really going somewhere. Its banks are lined with piers, small wharves, and all the usual impedimenta of the water front. It even has flotsam drifting on its bosom and jetsam cluttering its shores, just as though it were a big ocean. All of which is interesting enough, but the really exciting thing about Lake Buena Vista is that it sometimes tires of being a lake, and without so much as the passing of a local ordinance, it gradually shrinks and shrivels until it becomes as dry as a W.C.T.U. convention.

Some 25 years ago more or less, and if you don't believe it ask Al Tietze, Buena Vista became so thoroughly dehydrated for such a long time that enterprising farmers planted the lake bed in a variety of grains. The soil proved to be excellent and a mighty harvest resulted. So prolific, indeed was the yield that local mice sent word to their friends in all parts of the country, and soon they came squeaking and squealing by the thousands to sample the bounteousness of this bounteous area. The cereals were all they had been cracked up to be, and the story was still further noised abroad, until every mouse in the United States had taken up housekeeping in Buena Vista.

No sooner had the last delegate arrived than the rains came—in a big way; the lake began to fill up again, and the entire mouse population moved into Taft. There has never been such a mass infiltration in the history of the west. Legions of mice swarmed into town, storming larders, lunch boxes, pantries, and cupboards, and being just as acquistive and boresome as rodents can well be. Cheeseburgers disappeared like magic, and in fact all edibles were nibbled and scraped, until every morsel of solid food looked as though it had been gone over with a blacksmith's rasp. There was no Pied Piper to charm the invaders over a cliff, as there was in the village of Hamelin, so the townsfolk simply armed themselves with clubs and laid about them lustily. It was a bloody affray while it lasted, but there was no aternative—the mice had to be destroyed or the mice would destroy the people, and that as old man Euclid used to say is *reductio ad absurdam* or something. It took a little time to beat the mousy horde into submission, but the local citizenry aided by sundry Maricopans finally gave the little beggars such an unmerciful trouncing that to this day no mouse can be induced to step over the city limits of Taft.

●

And, having disposed of that historical tidbit, we now turn to more topical matters: The Beau Brummel of the equipment world, one Joe Siegel, who does a bangup job as membership chairman of the Petroleum Production Pioneers, recently took a group of trade press reps, Kobe executives, and advertising men on a wild safari into the lesser known parts of North Long Beach. Joe, in the lead car, was steering the expedition from the Dominguez oil field to one of the better eateries on Atlantic Avenue, but became so deeply involved in conversation with a passenger who shall be nameless that he lost himself hopelessly. Presently, he stubbed his front wheels against the dead end of a closed street and came to an abrupt stop while the other seven cars in the procession crowded in on top of him. Children gaped at the unusual parade and listened amazed as the drivers, following the example of H. K. Browning, raked the errant leader with a generous barrage of plain and fancy wisecracks. Joe withstood the attack admirably, but we note that he now packs a map, a compass, and a thermos bottle, whenever he is obliged to get off Slauson Avenue.

●

It was pretty rough on Bill Stewart breasting the tape first in the Honolulu yacht race with his Chubasco and only getting third place, which recalled our own tough luck in sports. The only race we ever won was a 100 yard dash for boys under ten when we were 14 years old. It also reminds us that when we

were a mere child over in Scotland, we used to take the tiller of a sloop or a yawl or something and sail away out into the Atlantic, under the command of a dour old uncle who swore at us terrifically in gaelic every time we allowed the mainsail to flutter. Since then we prefer to do our sailing in the lagoon at Balboa in a vessel propelled with gasoline instead of wind, and we simply can't stand anyone swearing at us in Gaelic. Speaking of Gaelic, and in line with our custom of including in this column, when it can't be avoided, little items of educational interest, we might mention that *shubasco* is not a sauce added to certain drinks to give them a tang. The word is Spanish and means "a gust of wind and rain, or a squall." You're welcome! Incidentally, still on the subject of the boat race, the Frank Morgan who won the Honolulu event is not the vice president of Richfield Oil Corporation who has acted in a number of Wildcat plays, but is another famous actor of the same name.

●

Seeping down to us via the grapevine is a report that Sam Kelly, the Bakersfield boulevardier, is launching out on his own as a manufacturers' representative, which prompts us to bet anything up to four bits that no matter what kind of goods or services Sam peddles, he will do a land office business. This lad has so many friends up in the Valley, we have often wondered if he owns a lodge near a trout stream or a cottage at the beach. We are told, however, that he comes by his friends honestly and from personal experience we can well believe it. The Bakersfield Hibernian is of the type that usually expresses its sympathies in action. If you need to have something done requiring a work gang, the feeding of 600 people with barbecued steaks, a mess of road equipment, or anything else that presents difficulty, just turn it over to Sam and from there on you can feel sure that it will be done—and on time. Having learned the Irish language, too, years ago, we unhesitatingly give three hearty ochones and a begorra for the success of the new enterprise.

●

About 1924, while we were still officiating feebly as research chemist for a large western oil company, we were one day mysteriously encircled and ushered into the photographic darkroom by a group of boys from the inspection laboratory. Once inside, everybody became as solemn as Ash Wednesday, and after several of the fellows had intoned some weird incantations with all the fervor of circus barkers and had made us repeat a succession of oaths and vows, it dawned on us that we were being initiated into something. Sure enough, at the conclusion of an imposing ritual we were given the grip, the password, and congratulations. From that day up to the present time we have been a somewhat lethargic member of a perfectly worthy fraternity. We can't remember all the boys who took part in the initiation ceremony, but two of them, then just boys in their first jobs, were Waldo Moore, the Cavins Company executive, also prominent in Nomadic affairs, and Jerry Rusk, the General Petroleum asphalt expert, who still columns for the fraternity magazine and does a right nice job of it, too. It will amuse both of these fellows to be reminded of the Shanghai atmosphere that pervaded the laboratory once for several months when a bale of cleanup rags turned out to be Chinese clothes and hats, much of it in pretty good shape. All the boys in the lab dressed up in the Shintoistic haberdashery, talked pigeon English, and in general comported themselves like followers of Chiang Kai-shek. The chief chemist never could bawl them out for their nonsense because every time he faced his crew of motley orientals, he would just get started talking when he would have to laugh.

●

John O. Hills, the well known trout booter-outer whose exploits have been recounted in this department from time to time has finally toppled from the ranks of bachelordom, and as we write is honeymooning in Carmel, whence he will proceed to the Top of the Mark for a good look at San Francisco. There is no truth, however, in the rumor that two-thirds of his baggage consisted of fishing gear. Johnny was married to a lovely ex-employe of General Petroleum Corporation, named Pat Sheldon, on July 13, with his brother-in-law, Charley Soper, a golfer of note, officiating as best man. The social aspects of the affair have already been done by the daily press, so we will skip any reference to the ladies' dresses and merely

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● Extra features that save you work make this RIDGID bench yoke vise more for your money. An integral pipe rest, a bender that won't flatten pipe, LonGrip jaws that protect polished pipe. Years of trouble-free service—special malleable frame and heat-treated tool-steel jaws for maximum wear. Eight sizes for pipe to 6 inches—look for the RIDGID red-top at your Supply House.

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remark that Hal Marsh did an excellent job of ushering at the church, and that the reception at the home of Mrs. Greer—of Greer-Robbins—was topnotch, mostly because of all the nice people that gathered there, but also to a measureable extent because of the champagne punch which, according to our informant, had an unusually high octane number.

●

Sam Keller in the last number of the *Parkersburg Rig and Reel* drew attention to the fact that the most disturbing and humiliating mishap that can befall any man is to lose his pants. And certainly there are lots of places a man can go with no money that he simply can't go with no pants. But, if it is a catastrophe to lose one pair of hand-me-downs, think of the predicament of John de Hetre, who lost two pairs in rapid succession on a reecnt fishing trip into the Canadian northwoods. The first pair just became tired of holding Johnny apparently, and insisted on coming apart in such embarrassing places that they had to be discarded. The second pair became uncomfortably damp during a fishing escapade, so he hung them over the camp fire to dry, and before he remembered to look again they were not only dry, they were dehydrated, and incinerated. Therefore he wore a blanket and became known to the Cree Indians in the vicinity as Chief Red-In-The-Face. Besides fire fighters, it's for people like Johnny that asbestos trousers were invented.

●

Just by way of a general roundup of last minute news, we might mention that among the better harmonizers heard at the Nomads' Whing Ding at the Riviera Club were Ralph Clemons, the Bethlehem Steel impresario who normally does his turf raising at the San Gabriel Club; Paul Huggins, Western Gulf exec, and reputed to have the fastest southpaw swing in western golf—when he winds up, you can actually hear him whir; Ernie Adams, the golden voiced tenor from Merco Nordstrom with whom we have participated in many a rousing roundelay over the years. Lee Laird provided a mighty nice show for the gang at the Nomad party, and Ray Humphreys did a neat job of presiding over the flying disks. We met Johnny Mason, convoying a group of interesting Frenchmen on whom we tried our high school patois with little success. Particularly remember a pleasant, personable gentleman, by name Yves Barbier, who is a petroleum engineer, and if our memory is as good as we thing it is, he is with the Societe Nationale Des Petroles D'Aquitaine. Yves is well acquainted with our good friend Guy Lynton in Paris, and that gave us a common bond. He was obviously having a grand time and finding life in Les Etats Unis quite to his liking. Bill Merrill, recently returned from South America, has been appointed resident geologist for Standard of California at Ventura, and only needs a house to make his joy complete. Walt Heathman has moved up to Olympia, Washington, to manage Union's affairs up there.

Had a visit from Martin Van Couvering just before he left on a trip that will take him to Denver, Chicago, and his erstwhile home in Michigan. Martin is one of the livest individuals in the geological business, and a gentleman to boot. His forum idea turned out to be tops and he has certainly done a lot of good for the Coast geologists, paleontologists, and geophysicists. Basically he is a petroleum engineer, but he is also a graduate paleontologist, and a natural student who is never quite content with what he knows. He has studied all his life and is still doing it. But busy as he is, he always has time for the little human acts that characterize the really worthwhile people in this busy old world. Consequently his friends are legion, and we are pleased to be numbered among them.

CNGA president installed

Frank J. Colton, superintendent of gas operations for the Tide Water Associated Oil Company, officially assumed the duties of president of the California Natural Gasoline Association at the annual meeting of the board of directors, July 8 at the Biltmore Hotel, Los Angeles, succeeding M. W. Kibre, General Petroleum Corporation. W. A. Kirk, California Southern Oil Company, another old timer in the industry became vice president. Kirk is an independent operator in Harbor City and Newport Beach.

In taking office Colton pointed out that the past year under the retiring president Mr. Kibre, had been one of marked

growth in membership, increased attendance at general meetings, and an increased prestige among other technical groups. Cooperative work of a technical nature has been carried on with the American Society for Testing Materials, Natural Gasoline Association of America, Pacific Coast Gas Association, and the Southern California Meter Association.

C. L. Case, Continental Oil Company, chairman of the Coastal chapter, which was organized last February, gave a report of its activities as did Harman Peahl, Taft chapter chairman.

Expands facilities in South America

J. C. Axelson, president and general manager of the Axelson Manufacturing Company, well known manufacturers of subsurface oil production equipment and heavy duty engine lathes, announces the completion of negotiations for an extensive sales and service organization in Venezuela and Colombia.

J. C. Axelson

Directly representing Axelson in sales and service, M. Ray Conger will be stationed at Caracas, Venezuela. Conger has been with the Axelson pump sales and service division since 1929.

For many years Axelson has been represented by C. C. McDermond at Maracaibo, Venezuela. Mac, as he is familiarly known, has through his ardent efforts and personal integrity established himself as a leading figure in the petroleum industry of Venezuela, Colombia, and Mexico.

McDermond's efforts are ably supported by John McNeill, who will be available from Maracaibo headquarters.

C. A. Industries, Waldrip y Campbell, recently formed by William S. Waldrip of Waldrip Engineering Company, Los Angeles, California, and W. J. Campbell, president of Petroleum Machinery Corporation, New York City, have established headquarters at Caracas, Venezuela.

The Waldrip Campbell organization with headquarters in Barcelona, Venezuela, will stock, sell and service the complete line of Axelson pumps and sucker rods in Venezuela and Colombia. In addition they will distribute and service Axelson heavy duty engine lathes and Axelson hollow spindle oil country lathes.

In the Walcam organization is C. T. McCoy, popularly described as a "bottom hole pump man," who worked in the Axelson sales organization and in the Axelson factory in Los Angeles for 22 years. The C. A. Industries Waldrip y Campbell has already made plans for machine shops of considerable size equipped to handle the wide variety of jobs demanded by the oil industry.

Whitney Chain moves Dallas office

The Whitney Chain and Manufacturing Company announces the removal on August 1 of its branch office and warehouse in Dallas, Texas, to new and larger quarters at 2914 Taylor Street.

J. W. Anderson, manager of oil field sales, will continue to make the Dallas office his headquarters. The new and larger quarters will enable the company to more adequately serve the oil industry through their distributing outlet, The Continental Supply Company. Whitney chain will also be better prepared to serve its industrial trade in all the southwestern states.

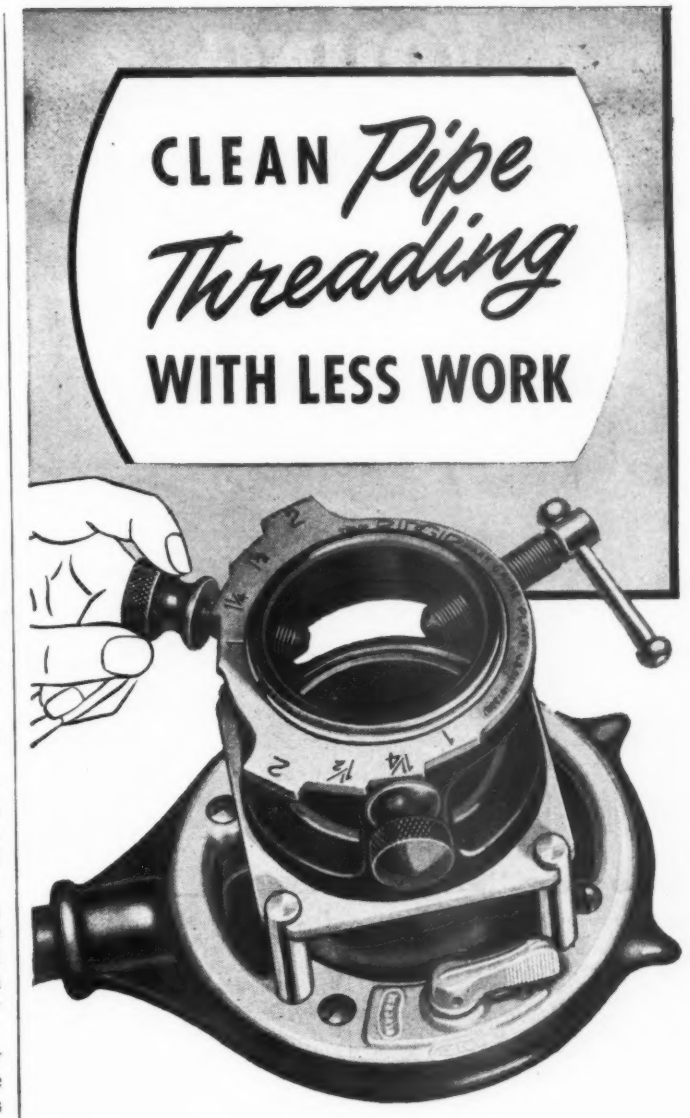
Public relations firm

Botsford and Billard, Inc., a new public relations firm specializing in industrial accounts, have opened offices at 31 West 47th Street, New York, New York. The principals are Harry Botsford and Jules B. Billard, who left the firm of Hill and Knowlton, Inc., to form the new company.

The officers of the new firm are: Harry Botsford, president, Jules B. Billard, vice president, Monica Holbert, secretary-treasurer, Evelyn Norton, office manager and assistant treasurer.

Opens Jackson, Mississippi, office

The Continental Supply Company has announced the opening of an office in Jackson, Mississippi, at 702 Deposit Guaranty Bank Building. This office is now the headquarters of B. L. Hindman, assistant district manager for the state. Hindman formerly was at the Brookhaven store.



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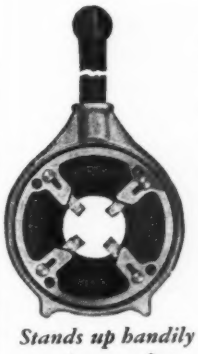

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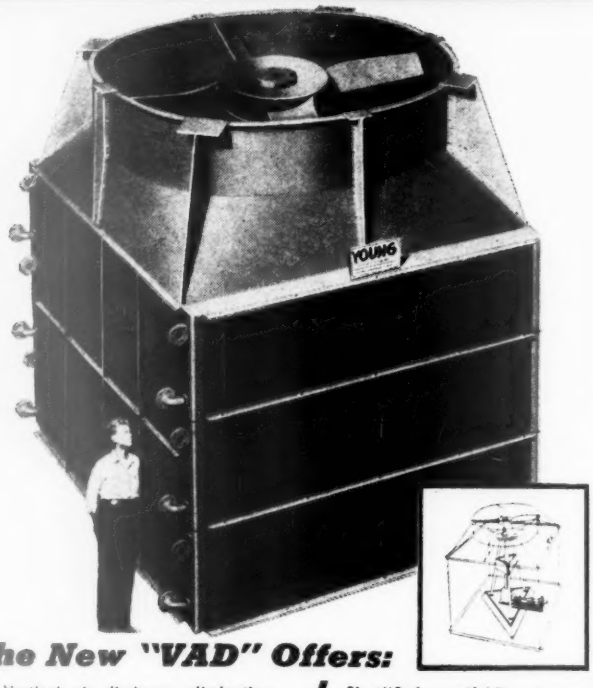

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Michigan Area: H. J. YOUNG, 1364 Lake Shore Drive, MUSKEGON, MICHIGAN

Makes 18,000-airmile trip

In two wide aerial circles over the oil centers of South America and Europe, Elmer Weis, vice president of Pacific Pumps, Inc., Los Angeles, California, one of the Dresser Industries, just completed a survey that brings his company abreast of the latest developments.

Elmer Weis

With a world shortage of oil and a tempo accelerated everywhere oil is produced and refined, all industries identified with petroleum equipment are on their toes to acquire information likely to aid them in planning supply to fit immediate demand. Weis left Los Angeles by air early this year to sweep into the South American refining centers for meetings with officials of Royal Dutch Shell, Lago Oil and Transport Company. and others. From his first stop at Curaco, he went on to Aruba and then flew to other refining and producing areas in Venezuela and Colombia. He returned by way of the Canal Zone and Mexico City. At this last stop he met with officials of Petroleos Mexicanos. Efficiency of oil pumps produced by Pacific Pumps, Inc., was demonstrated by the California official to interested groups and industries wherever he traveled.

Returning from this South American trip, Weis left immediately for a tour of the European refineries. This journey during April, May, and June, carried him to England, France, and Holland. Wherever Weis went in Europe, he stated that plenty of Pacific's petroleum equipment was in evidence. Encouraged by marked increases of interest in the availability of Pacific's pumping equipment, Weis states that every effort will be made to supply the special needs of the old world as speedily as possible as another step in aiding the recovery of the war-torn countries there.

Nelson assistant to the president

President James E. DeLong of the Waukesha Motor Company has appointed Chas. E. Nelson, Jr., his special assistant with title of assistant to the president—a newly created post effective July 14 last.

Chas. E. Nelson, Jr.

Nelson entered the Waukesha Motor organization in 1929 after several years as state wholesale representative for a major motor car manufacturer. His earliest activities with the Waukesha Motor Company were connected with the financial department and led to his appointment as secretary and treasurer of the Faegol Truck and Motor Coach Company of Oakland, California, which in 1933 became a subsidiary of the Waukesha Motor Company. Returning to Waukesha in 1934, he became factory production manager, and since June, 1936. has been director of purchases and production planning. His new duties will be in addition to his past responsibilities, which he will continue to discharge.

Mr. Nelson is widely known in the purchasing and management fields, having been president of the Milwaukee Chapter of The National Office Management Association and a member of The Milwaukee Association of Purchasing Agents for a number of years. He was recently elected a director and member of the executive committee of The Internal Combustion Engine Institute, replacing James E. DeLong, a former president of the Institute. He is also a director of The Waukesha National Bank.

Industrial representative

The Aldrich Pump Company of Allentown, Pennsylvania. recently announced that the Petroleum Machinery Company. 30 Rockefeller Plaza, New York City, which has represented Aldrich Pump Company in the petroleum export field, has been appointed industrial representative in the New York area. This company will handle all Aldrich products in the industrial field.

The marine field will continue to be represented by William O. Mulheron, 11 Broadway, New York City.

Non-existent telephone lines

To The Petroleum Engineer:

The article, "Why the Middleman Is Helpful," (March, 1947), is an engineering analysis of an economic problem, and was therefore, as your editors must have felt, of interest to engineers. However, a portion of the mathematics, while making the point, was, as printed, too far out of line to "get by" without comment.

Referring to the article (page 64), the number of manufacturer-dealer transactions and diagram was entirely correct, but when the author introduced the analogy of 20,000,000 telephones in the country each connected to all others if there were no "centrals," he arrived at a resulting 400,000,000 lines. Perhaps the typesetter ran out of zeros, but on the basis of twenty million times twenty million the answer would be 400 trillion!

However, the number of combinations of n things taken r at a time is:

$$\frac{n(n-1)(n-2)(n-3)\ldots(n-r+1)}{r!}$$

where $r!=r(r-1(r-2)\ldots.2$

when r=2 the number reduces to

$$\frac{n(n-1)}{2}$$

The number of telephone lines required to interconnect each 20 million telephones directly would then be:

$$\frac{(20{,}000{,}000)(20{,}000{,}000)-20{,}000{,}000}{2}$$

or 199,999,990,000,000

We might settle for 200 trillion as an estimate. After all, what is (or should I say are) 10,000,000 non-existent telephone lines between friends? But 199,999,990,000,000 non-existent telephone lines—uh, *uh!* That's a few too many, too few, non-existent telephone lines. Very truly yours,

D. M. JONES,
Axelson Manufacturing Company,
Los Angeles, California.

Sells governor business

In the interest of centering manufacturing facilities on its principal lines, Gardner-Denver Company has sold its governor business to the Wiebmer Machine Shop of Quincy, Illinois, Gardner-Denver officials recently announced. Gardner-Denver henceforth will concentrate on its expanding business in rock drills, air compressors, pumps, and other allied products.

Governors have been a part of the Gardner-Denver line almost since the company's founding in 1859 by R. W. Gardner and his son, J. W. Gardner. The early activities of the company were confined to the manufacture of fly ball governors for steam engines. With the passing of steam as the principal source of power, the company expanded into other lines, namely air compressors, pumps, and rock drills.

Joins engineering organization

The California engineering and construction firm of J. B. Gill Company recently announced an association with Edw. G. Ragatz, absorption process specialist, for the purpose of rendering a complete and advanced processing, engineering, and construction service to the oil industry in the field of natural gasoline recovery.

Ed Ragatz has been actively identified with natural gasoline for the past 20 years, and is nationally recognized for his many technical contributions to the industry. During this period he has initiated numerous advances in plant process and engineering designs, while contributing extensively to the technical literature.

His latest technical contribution is the "Straight-Line Chart" method of evaluating absorber performance, which method gives promise of developing into one of the industry's most effective process tools.

The Gill organization, now under the direction of Glen J. Gill since the retirement of its founder, J. B. Gill, a year ago, has served the industry for the last 25 years.

Harry R. Marsh, the company's chief engineer, adds 20 years' diversified experience in the engineering and construction field to this new, well balanced combination.

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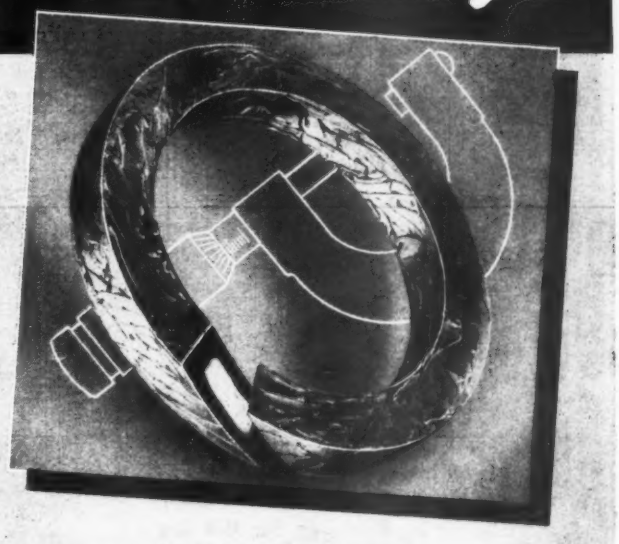

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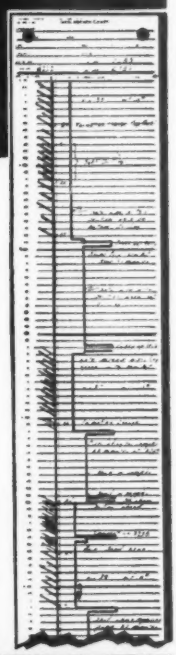

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● **Men, Oil and War, by D. Thomas Curtin.** *Published and distributed by the Petroleum Industry Committee, District Number Two, for the National Archives. Pages, 360.*

A drama of work in the war of oil men of the Middle West and the Gulf States, who rushed oil overland to save the East—when the East rushed tankers to save the United Nations. Although prepared for the National Archives, this story is presented with a simplicity and clearness that will attract the general reader.

From the government's request for a report for future reference has emerged a graphic description of the performance by the oil fraternity in 15 midwestern states, which furnished petroleum products to the armed forces and kept the essential civilian needs supplied. Pipe lines, rail tank cars, Great Lakes tankers, river barges, and tank trucks were used to their maximum capacity; refineries were adjusted to war requirements, and many diverse interests and personalities were united to become a smoothly operating part of the war machine.

To those who took an active part in the industry during that period it will bring a renewed pride in the part played in the critical period. To those outside the industry it will give a keener insight into the problems faced by the industry and the ingenious means devised to carry out the essential work under wartime handicaps.

● **Concise Chemical and Technical Dictionary,** *edited by H. Bennett. Published by the Chemical Publishing Company, Inc., 26 Court Street, Brooklyn 2, New York. Pages, 1120. Price, $10.*

Fifty thousand authoritative definitions lie at the fingertips of every professional and layman, in this up-to-date Chemical and Technical Dictionary. It is evident that a great deal of effort was made to obtain accurate information for this volume, which covers every field of scientific and technical development.

New features found in this dictionary are welcome additions. There is compilation of thousands of trade-names or proprietary products in the various fields, with their chemical and physical properties, applications, and chemical composition. Cross-references and abbreviations are helpful. Many useful tables, such as conversion tables, organic ring systems, and vitamin values of foods are handy aids. New and rarely used technical terms are defined.

General rules for the pronunciation of chemical terms recommended by the American Chemical Society and a list of key words with their phonetic spelling and diacritical marks facilitate pronunciation of chemical names.

● **Management and Human Relations in Industry,** *Volume I, edited by Paul Anderson, assisted by a board of experts. Industrial Relations Publishing Corporation, 1165 Broadway, New York 1. Pages, 103. Price, $2.00.*

This timely symposium covers the many factors governing management and human relations today. Lincoln Electric Company's incentive plan is covered thoroughly. Taxation, banks, labor relations, economy, and views of the future are given their share of attention by leaders in their various fields.

The plan of giving the worker an incentive for pride in his labor and responsibility for his progress—thereby becoming more than a cog in the machine—was successfully applied at Lincoln Electric. The same attitude offers a possible solution for better human relationships in industry.

● **Petroleum Production,** *Volume III, Oil Production by Water, by Park J. Jones. Reinhold Publishing Corporation, 330 West 42nd Street, New York 18. Pages, 271. Price, $5.00.*

Third in a series on oil production, this volume is concerned exclusively with oil production by water. Two previous volumes covered mechanics of production and optimum rate of production.

Trap-forming combinations of structure and stratigraphy are

discussed. Principal factors in production by water are given, with all terms analyzed and explained for use in maximum production. Practical use of the fundamentals is applied to various type reservoirs. Numerous charts and illustrations show graphically the problems involved and their solution.

War veteran employes

Wendell M. Jones, vice president and general manager of Bethlehem Supply Company of California, has announced that more than 30 per cent of the oil field supply company's employes are veterans of World War II.

Jones, a World War I veteran himself, pointed out that the percentage of ex-servicemen in the general managers, accounting, field stores, sales, and warehouses was approximately 40 per cent.

Bethlehem Supply, a subsidiary of Bethlehem Pacific Coast Steel Corporation, operates ten oil field supply stores and two warehouses in California.

Sperry-Sun sales manager

Appointment of Arthur B. Palmer as general sales manager of the Sperry-Sun Well Surveying Company, is announced by Jno. G. Pew, president of Sperry-Sun, and vice president in charge of production of the parent Sun Oil Company.

Palmer joined Sun Oil Company as an engineer at Maracaibo, Venezuela, in 1922, immediately after his graduation from the University of Illinois where he received a degree in civil engineering.

He joined the Sperry-Sun Well Surveying Company as a sales and service engineer in 1929. Since 1938 he has been a district manager for Sperry-Sun with headquarters at Lafayette, Louisiana.

Twin Disc personnel changes

N. F. Adams, vice president in charge of sales and engineering for the Twin Disc Clutch Company of Racine, Wisconsin, has announced the appointment of C. F. Mohrbacher as assistant sales manager of the Racine division. Other appointments relating to the home office and several of the sales territories, include:

A. E. Young as district manager of the west coast territory, including California. Young has previously been in charge of the company's sales activity of the Northwest territory as handled through the company's branch offices at Seattle.

E. H. Bennett as district manager of the eastern territory. Formerly assistant district manager in charge of the territory served by the company's Dallas factory branch, his headquarters now will be in the company's Newark office. W. L. Dixon will continue his association with the Newark office in the capacity of consulting sales engineer.

J. B. Jenkins as district manager of the Michigan territory, with headquarters in the company's new sales office, which was opened in Detroit on August 1.

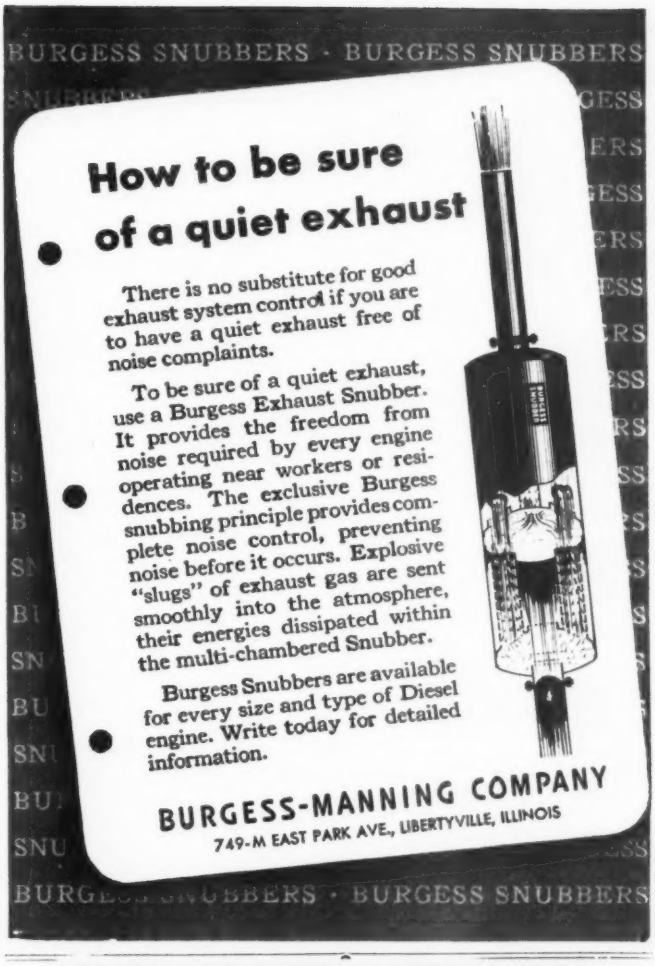
P. G. Tyrrell as assistant district manager in the territory served by the new Los Angeles office. He formerly was in the sales department of the hydraulic division at Rockford, Illinois.

P. W. Waller as assistant district manager in the territory served by the Seattle factory branch. He was formerly in the New Orleans office.

Wade A. Eskridge as assistant district manager in the Mid-Continent territory to take charge of operations in the Tulsa office. H. A. Davis, manager of the Mid-Continent territory, has shifted his headquarters from Tulsa to Dallas.

BS&B semi-annual report

Black, Sivalls and Bryson, Inc., Kansas City, Missouri, have issued their semi-annual report, covering the period from January 1, to June 30, 1947. As in the past, the financial report of this manufacturer of oil-field equipment reveals healthy progress. Significant is the fact that for the six-month period the company's gross sales were $6,459,831.54 and its net profit before taxes was $1,362,241.61. Assets are shown by the report to be $10,093,737.58. For the first half of the year cash dividends on preferred stock were on a basis of 4.25 per cent, and 45 cents a share was paid on common stock.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